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THE PROCEEDINGS

OF THE

THIRD
ALL-INDIA
SANITARY CONFERENCE

HELD AT

LUCKNOW

January 19th to 27th, 1914

VOLUME V

PAPERS

CALCUTTA
W. THACKER, SPINK & CO

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TABLE OF CONTENTS

MOSQUITOS.

PAGE.

Synoptic arrangement of Indian anophelines with reference to teaching requirements.—Major S. R. Christophers, M.B., I.M.S. 1

Note on experiments to determine the reaction of mosquitos to artificial light.—Dr. C. A. Bentley, M.B., D.P.H., D.T.M. & H. 7

KALA-AZAR.

Kala-azar in Assam.—Captain F. P. Mackie, M.B., F.R.C.S., M.R.C.P., I.M.S. ... 9

The bearing of Assam tea garden experience on the problem of the etiology of kala-azar.—Lieut.-Colonel L. Rogers, C.I.E., M.D., F.R.C.P., F.R.C.S., I.M.S. 11

Report on the progress of the kala-azar investigation during the season 1912-13.—Captain T. C. McCombie-Young, M.B., D.P.H., I.M.S. ... 15

BACTERIOLOGY OF WATER.

The bacteriology of the Colombo town and well water.—Dr. L. F. Hirst, M.D., D.P.H. 30

FILTRATION OF WATER.

Experiments in the filtration of water through slow sand and mechanical filters at the King Institute, Guindy, Madras.—Mr. W. Hutton, A.M.I.C.E. 42

INSPECTION OF LUCKNOW SANITATION AND TOWN IMPROVEMENT.

Note on the working of the Co-operative Dairy Society at Lucknow.—By Major S. A. Harriss, I.M.S. 56

Note on the institution and management of Co-operative Dairies in the United Provinces, with special reference to the Co-operative Dairies in existence at Benares and Lucknow.—By Mr. R. W. D. Willoughby, I.C.S... 62

Note on Lucknow.—By the Hon'ble Rai Ganga Prasad Varma Bahadur ... 66

Short descriptive note on Lucknow City Sanitation.—By Mr. P. R. Hewlett, A.M.I.C.E. 73

Lucknow Water-Works.—By Mr. H. I. Carter, A.M.I.M.E. 76

A new Filter-Bed Flow Controller 77

PLAGUE.

Further investigations into the persistence of plague infection in the villages of Poona district during the off-season.—Captain J. C. G. Kunhardt, I.M.S. 78

Plague prophylactic measures during the off-season.—Captain J. C. G. Kunhardt, I.M.S. 85

Rat destruction and plague.—Lieut.-Colonel S. Browning-Smith, I.M.S. ... 107

The use and advantages of hydrocyanic acid gas as a disinfectant for plague-infected houses and ships.—Major W. Glen Liston, C.I.E., M.D., D.P.H., I.M.S., and Capts. W. D. H. Stevenson, M.B., I.M.S., and J. Taylor, M.D., D.P.H., I.M.S. 110

VITAL STATISTICS.

Note on some points of interest regarding vital statistics.—Dr. C. A. Bentley, M.B., D.P.H., D.T.M. & H. 120

Note on some simple methods of testing the registration of vital occurrences in India.—Dr. C. A. Bentley, M.B., D.P.H., D.T.M. & H. ... 126

VITAL STATISTICS—*continued.*

PAGE.

Registration of vital statistics.—Capt. T. C. McCombie-Young, M.B., D.P.H., I.M.S. 128

Note on the registration of vital statistics in Sind.—Major W. Murphy, M.B., D.P.H., I.M.S. 130

THE USE OF CAST-IRON, STEEL AND FERRO-CONCRETE PIPES FOR WATER-SUPPLY AND DRAINAGE SYSTEMS.

Note on a reinforced concrete pipe for Ahmednagar water-supply.—Mr. T. S. Pipe, B.SC., A.M.I.C.E. 132

STATISTICS OF CONSUMPTION OF WATER IN WATER-WORKS.

Prevention of waste in water-supplies.—Mr. C. H. West 135

STATISTICS OF PUMPING PER PUMP HORSE-POWER, PER HOUR.

Notes on comparative cost of pumping at various water-works in the Central Provinces.—Major L. W. S. Oldham, R.E. 149

BENARES.

Benares—I. Drainage—II. Minor Improvements—III. Water-Works—Mr. C. A. C. Streatfeild, I.C.S. 154

SYNOPTIC ARRANGEMENT OF INDIAN ANOPHELINES WITH REFERENCE TO TEACHING REQUIREMENTS.

BY

MAJOR S. R. CHRISTOPHERS, M.B., I.M.S.

A SYNOPTIC table by James and Liston[1] of the species of Anophelines occurring in India was the first attempt in any tropical country to bring the identification of anophelines within the easy reach of the general worker. More recently this table has been revised by the authors and a table on somewhat similar lines has been issued by the Central Malaria Bureau. Tables of the same kind have beed drawn up by Mathis and Leger[2] for the anophelines of Tonkin, by James ann Stanton[3] and by Strickland[4] for Malayan species and by Edward[5] for the African anophelines.

At first sight it might seem that it mattered very little in such tables what particular characters were used to differentiate the species, or in what order these characters were employed, so long as a correct dichotomous table was the result. This, however, is not so when the table is intended for those who are not professional entomologists and when not only the medical man but also members of the subordinate services are intended to use them. In my experience a table drawn up without very careful consideration of certain points is apt to be full of pitfalls for the inexperienced.

The difficulties in the use of a synoptic table are mostly due to :—

(1) The tendency to variation in the same species. This is perhaps the most important difficulty to be considered.

(2) The difficulty on the part of the beginner to be sure what the appearances actually shewn by a given specimen really are, and especially his inability very often to make use of merely comparative characters.

(3) Ambiguity in wording.

To avoid these difficulties it is necessary—

(1) To give prominence to points of distinction as far as possible in the inverse order to their liability to exhibit variation.

(2) To give most prominence to the most easily determined characters.

(3) To avoid using comparative characters and possibly ambiguous terms.

The table recently issued by the Bureau was an attempt based on practical experience in teaching to meet these requirements, and I may remark that apparent complexity in a table of such a kind may really give better results with a beginner than a seemingly simpler table which has attained its simplicity by ignoring variations and the like. Thus it is useless for example to "place" the species *N. fuliginosus* by means of three-banded palps when it not infrequently shews four palpal bands. Each time the beginner gets a four-banded specimen he is naturally completely misled.

There is another point on which I wish to lay chief stress in this note. At present it is necessary in teaching the identification of anophelines first to teach the method of using an entirely artificial synopsis of the species based on markings, and then on an entirely different basis to proceed to teach the characters of the different groups by scale structure, a proceeding which is most unsatisfactory and confusing. I hope to shew that by a proper selection of synoptic points tables can be drawn up based on markings only, which not only give a natural grouping but may be made to embrace all the most distinctive features of a classification based on scale structure. Such tables are the more necessary at the present time owing to the differences of opinion which exist as to the value of so-called genera and the desirability of a compromise between those who discard generic distinctions among the anophelinæ altogether and those who still retain in some form or another Theobald's scale groups.

In practice, once one is familiar with anophelines, identification is conducted as a rule by a much more rapid method than that given in synoptic tables. One

sees at once very often that a particular specimen belongs to one of a small group of species. Working on the idea that such subconscious grouping was probably very largely based on real natural affinities, I was led to study what I may call the comparative morphology of colour markings in anophelines.

As a result of this work I suggested[6] the sub-division of the anophelinæ into three main groups *Protoanopheles*, *Deuteroanopheles* and *Neoanopheles*, the differences between which are most fundamental.

In the space at my disposal I cannot do full justice to these distinctions but will mention some of the most obvious differences. If a large series of anophelines wings be examined it will be found that the markings are essentially due to pale spots developed on an originally dark ground and that these spots originate at certain definite anatomical points. The spots are of two kinds, those appearing at certain anatomical junctions which I have called *nodal*, and those making their appearance usually half way between two nodal points which I have called *internodal*. The nature of this distinction will be clear from the diagram. Confining ourselves for the present to nodal points it will be seen that one such point is at the junction of the subcostal vein with the costa, another where the first longitudinal joins the wing margin, others wherever a cross-vein joins a longitudinal vein, where the forked second and fourth veins bifurcate and so on. Each one of these nodal points has the inherent power to develop a pale spot. More than this each has a proper order of precedence in which it is, as it were, allowed to act and this order of precedence is with some minor exceptions universal among anophelines. If there is only one spot it is that shewn in the diagram towards the apex of the wing. If there are two the second one will always be that at the subcostal junction and so on.

There is this difference between *Protoanopheles* and *Deuteroanopheles* that whilst in the former the development of nodal spots never progresses beyond the stage at which the cross vein terminations are still dark, in the latter the process has gone further and involved a second series of points, *viz.*, those at the cross veins and bifurcations of the longitudinals. This I have found to be the most satisfactory character on which to base these two divisions. For the purpose of a synoptic table there is another feature we can use. In the *Protoanopheles* there are usually developed only one, two or three pale areas on the costa. In the *Deuteroanopheles* there are always (except in an occasional freak) four dark costal spots due to the development of all the nodal points of the costa. These four dark costal spots are the same in all *Deuteroanopheles* and a deuteroanopheles wing is therefore recognisable at a glance.

It must not be imagined that these two points chosen as most suitable for a synoptic table are the only or indeed the most striking differences between the sub-divisions I have mentioned. On certain wings there exist spots on the veins due not to pale scales but to aggregations of dark, usually somewhat enlarged, scales. Spots of this kind are very familiar in the case of *A. maculipennis* in which species there being no other spotting the dark spots are very conspicuous. But a similar condition is present in a great many species of anopheles. These scale aggregations are always at the same points whatever the species and it is interesting to note that these points are the nodal points. Spotting of the kind I have described is highly characteristic of the Protoanopheles group. It is never seen in the Deuteroanopheles.

Again if the scales on the under surface of the wing of an anopheles be examined it will be found that ordinarily any pale spot on the upper surface is represented by pale scales on the lower. But in some species many spots on the upper surface are unrepresented on the lower. This lack of correspondence between the two surfaces of the wing is confined to the Protoanopheles.

Still another point is the occurrence in many of the Protoanopheles of mixed dark and pale scales on the wing veins giving these a mottled appearance. This is never seen in the Deuteroanopheles and is another prerogative of the Protoanopheles.

Still more important is the fact that the larval characters of the two groups differ. Throughout the Deuteroanopheles the antenna of the larva does not carry any branched hair, whilst the leaflets of the palmate hairs are of the kind which possess shoulders and carry a filament. In the Protoanopheles the presence of a branched hair on the antenna is almost universal, whilst the palmate leaflets are of the serrated lanceolate type without a filament.

The wing markings of anopheles are of course very various. But in the Deuteroanopheles, to which class the majority of anophelines belong, there is one definite pattern which is adhered to throughout, all the variations seen being merely various degrees of development of the same identical colour pattern scheme. What this scheme is I shall briefly indicate.

In a Deuteroanopheles wing all the nodal points, with the exception of those on the wing fringe and one other, which may or may not be present, are developed. The internodals have, however, still to be considered. These like the nodals adopt

a regular sequence of precedence. If there is only one it is always that on the lower branch of the fifth. If we put this as a pale spot on a diagram in which the nodals have been already filled in, we have the wing of a variety of *A. funesta* (or *A. nili*. Theo.). If we add the next internodal in order (that on the sixth vein) we have the wing of *A. culicifacies*. The full development of the next internodal gives us what is usually spoken of as a pale third longitudinal. When this happens the nodals on the wing fringe (all except that at the sixth vein) appear as pale spots and the result is the wing of *A. listoni* and a number of other species. This is the extent to which the colour scheme is developed in *Myzomyia*. Adding in due course the internodals on the limbs of the forked cells, one on the branch of the fifth and one on the sixth vein we get the wing of *A. nursei* and other species of *Pyretophrous*. At this stage the last of the nodal points, namely, the fringe spot at the sixth vein and the spot that gives the triple character to the middle costal spot in *A. maculatus* appear. The full development of all the nodals and internodals has now given us the *Nyssorhynchus* wing. Though no more pale spots appear, development of the pattern is still possible by the further extension of the existing pale areas and the obliteration of intervening dark areas. This is well shewn in the wing of some *Cellias* and the *A. rossi* group.

As I have previously said it is possible at a glance to say whether a specimen exhibits some stage in this colour pattern or not, and further if one wished to do so one could use suitably selected spots to assist one in classification. In the table accompanying this paper I have by choice selected more conspicuous characters than wing spots when possible, but I have in places made use of particular wing spots. From what I have just said in this respect it will be clear that the presence or absence of a particular spot may have a deeper significance and imply much more than has hitherto been supposed.

Time being limited I cannot go into all the reasons which underlie the arrangement in the table, but you will see that by the employment of such characters as are in ordinary use for synoptic tables a sub-division of species is arrived at which corresponds with the scale character groups, the names of which are printed in the margin of the table to bring out this point. The scale characters themselves are in small type for reference, under the group to which they relate. I could take many points to illustrate the naturalness of the arrangement given in the table, put I will mention only one rather interesting structural variation and shew how it confirms some of the divisions made.

In the anopheline palps there are four clearly distinguishable segments, the lengths of which observe a certain relation to each other. In most anopheles this relation is such that the fourth segment is somewhat more than half the length of the third, which in turn is slightly shorter than the second. When a palp keeps these proportions I have called it an "orthodactylous" palp. Two variations occur which form two types of "heterodactylous" palp. In one type the second segment is disproportionately long and the third disproportionately short. This kind of palp is absolutely characteristic of my first group which is Theobald's *Stethomyia*. In the other type of heterodactylous palp it is the terminal segment which is disproportionately short. This form of palp is a highly distinctive feature of the two genera *Myzomyia* and *Pyretophorus* and of these only. It might be used quite well to separate, for example, the rossi group which has orthodactylous palps from the true myzomyias. In the table, however, I have used the character of the tarsal banding which also serves this purpose.

Even if for the sake of making things as easy as possible to the beginner too much stress is not given to the generic (or doubtfully generic) divisions of the anophelinæ I think the main groups of Proto—, Deutero— and Neoanopheles are too natural and important to be omitted. So far from complicating matters they make the markings and scale characters of anopheles much easier to understand.

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Annals of Trop. Med. and Parasitology. Vol. VII, No. 1. .. [March 1913.

SYNOPTIC TABLE OF INDIAN ANOPHELINES.

(Arranged to demonstrate a natural grouping.)

Costa with less than four main dark spots (*i.e.*, dark spots represented both on costa and first longitudinal). Site of bifurcations of 2nd and 4th longitudinal veins without pale interruptions. (Protoanopheles).

Costa without any pale spots (even at tip of wing).

STETHOMYIA

Attitude culex like. Female palps have second segment (from base) more than twice length of third segment.

(*Scale characters. Head scales narrow, linear, not expanded as in all other anophelines. No scales on prothorax, mesothorax or abdomen*).

- Anterior forked cell double length of posterior . . . — A. AITKENI.
- Anterior forked cell only slightly longer than posterior . . — A. CULICIFORMIS.

ANOPHELES (sense of James).

Attitude anopheles like. Female palps of ordinary anopheline character.

(*Scale characters. Head scales expanded as in ordinary anophelines. No scales on prothorax, mesothorax or abdomen. Wing scales large fusiform.*)

- Palpi unbanded . . . . — A. BARIANENSIS.
- Palpi diffusely banded . . . — A. IMMACULATUS.

Costa with at least one spot which may be at apex.

Basal portion of costa entirely dark.

LOPHOSCHELOMYIA.

Femur with conspicuous white band.

(*Scale characters. Head scales expanded. Prothoracic tuft present. No scales on mesothorax. Scales on genitalia or last few abdominal segments.*)

- White band on femur associated with scale tuft . . . . — A. ASIATICA.
- White band on femur not associated with scale tuft . . . . — A. LINDESAYI.

MYZORHYNCHUS

Femur without band.

(*Scale characters. Head scales expanded. Prothoracic tuft present. No scales on mesothorax. Scales on genitalia or on last few abdominal segments. A single ventral tuft of scales on penultimate segment of abdomen (not always present).*

Palpi unbanded.

- Spot on costa at junction of subcostal vein very inconspicuous, ventral tuft absent. Palps not so shaggy as next species (chiefly Malayan) . . . . — A. UMBROSUS.
- Spot on costa at junction of subcostal vein distinct, ventral tuft present and conspicuous, palps very shaggy . . . . — A. BARBIROSTRIS.

Palpi banded . . . . — A. SINENSIS.

Basal portion of costa with pale area.

PATAGIAMYIA ..

(*Scale characters. Head scales expanded. Prothoracic tuft present. No scales on mesothorax or abdomen*).

- Palpi unbanded . . . . — A. GIGAS.
- Palpi banded . . . — A. SIMLENSIS.

Costa with at least four main dark spots. Sites of bifurcations of 2nd and 4th longitudinal vein shew pale interruptions.

Sixth vein has not more than 3 dark spots. (Deuteroanopheles).

Tips of hind tarsi not white.

MYZOMYIA

Tarsal joints not broadly banded. (Palps heterodactylous).

(Scale characters. Head scales expanded. No prothoracic tuft, no scales on abdomen. Mesothorax may have hair-like or false scales only (—Myzomyia) or shew covering of obvious scales (—Pyretophorus).

Palpi with 2 broad apical bands . . A. ALBIROSTRIS.
Palpi with apical band only broad.
Third longitudinal vein dark . . A. CULICIFACIES.
Third longitudinal vein light.
Fringe spots 2 only . . A. CULICIFACIES.
Fringe spots at all except 6th vein.
Tip of palpi white.
Tarsi unbanded.
Conspicuous scales on thorax A. NURSEI.
False scales only on thorax A. LISTONI.
Tarsi narrowly banded . A. JEYPORENSIS.
Tip of palpi dark.
Conspicuous scales on thorax A. NIGRIFASCIATUS.
False scales only on thorax A. TURKHUDI.

PSEUDOMYZOMYIA .

Tarsal joints broadly banded. (Palps orthodactylous).

(Scale characters. Head scales expanded. No prothoracic tuft, a few broad scales on thorax mostly false scales (rossi and ludlowi). Covered with broad scales (stephensi), abdomen with a few scales on last segment (rossi and ludlowi) or scales on many segments (stephensi).

Palpi with apical band only broad.
Legs not speckled . . . . . A. ROSSI.
Legs speckled . . . . . A. LUDLOWI.
Palpi with two broad apical bands . . A. STEPHENSI.

Tips of hind tarsi white.

NYSSORHYNCHUS (Including Neocellia and Christophersia).

Sixth vein with three dark spots.

(Scale characters. Head scales expanded. No prothoracic tuft, mesothorax with covering of obvious scales, abdomen with scales on last few segments or on all segments (Neocellia) but no lateral tufts present.)

Legs not speckled.
Two or three tarsal segments completely white.
White band at junction of 1st and 2nd tarsal segments . . A. FULIGINOSUS.
Junction of 1st and 2nd tarsal segments not showing band . A. FOWLERI.
One tarsal segment only completely white, 4 broad white bands on palps . A. KARWARI.
Legs speckled.
Two or three tarsal segments completely white.
Palpi with one broad apical band only A. JAMESI.
Palpi with two broad apical bands.
Three tarsal segments completely white, palpi speckled . . A. MACULEPALPIS.
Two tarsal segments completely white with broad white band above this, palpi not speckled A. THEOBALDI.
One tarsal segment or less completely white.
Palpi with 4 broad white bands, ventral tufts on each abdominal segment. Half last tarsal only white . . . . A. KOCHI.*
Palpi with 2 broad apical bands only (3 or 4 bands in all).
Many scales on abdomen . A. WILLMORI.
Scales only on last segments . A. MACULATUS.

* Has prothoracic tuft.

CELLIA . . .	Sixth vein with 2 dark spots only . . .	A. PULCHERRIMA.
	(*Scale characters. Head scales expanded*). *A few scales* (*no tuft*) *or prothorax, mesothorax with covering of obvious scales, abdomen with complete scaly covering and lateral tufts.*	
Sixth vein has more than 3 dark spots. (Neoanopheles).		
NEOMYZOMYIA .	(*Scale characters. Head scales expanded*), *prothoracic tuft present* (*elegans*) *or absent* (*punctulata*). *A few scales on terminal segment of abdomen mixed with hairs.*	
	Tibio-tarsal joint on hind legs broadly banded white	A. ELEGANS.
	Tibio-tarsal joint on hind legs not broadly banded	A. PUNCTULATA.

NOTE ON EXPERIMENTS TO DETERMINE THE REACTION OF MOSQUITOES TO ARTIFICIAL LIGHT.

BY

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Special Deputy Sanitary Commissioner, Bengal.

THIS brief note deals with the results of certain experiments carried out with a view of finding out whether or not mosquitoes respond to certain influences likely to bring them into close contact with human beings.

On consideration, the simplest method of answering this question appeared to be by testing the response of mosquitoes to artificial lights. If on the one hand experiments showed that they were attracted towards lamp light or fire light we should at once be in a position to state that they tended to be attracted to the neighbourhood of human beings who make use of such artificial lights; on the other hand, if the results of such experiments were negative, it would be necessary to carry out tests of a different nature.

For carrying out the experiments a number of boxes, type A, were constructed measuring about 30 × 12 × 12 inches. These boxes which were lined with black cloth were open at both ends and could be arranged to form a long light-proof tunnel. Other boxes, type B, about 15 × 12 × 12 inches in size were also constructed and also lined with black cloth. One end of these boxes was covered with mosquito netting and the other end was provided with a large sliding door. Light-tight shutters were added which could be fixed immediately over the end closed with mosquito-netting. A third type of box C 15 × 12 × 12 inches in size was also made and lined with black cloth; but one end was completely closed and the other was fitted with a large sliding door. A small shutter through which mosquitoes could easily be inserted in the box was also provided. The following experiments were conducted at night between 7 P.M. and 10-30 P.M.

In the first series of experiments two tunnels about 12 feet long were arranged side by side. At the end of one tunnel a box type B, but without the shutter over the mosquito netting was placed. The end of the other tunnel which served as a control was closed by means of a similar box type B, but with the light-tight shutter in position. Two boxes of type C, each containing about 30 freshly caught mosquitoes (including both male and female *N. fuliginosus* and *Mansonia uniformis*) were then placed in position before the mouth of each tunnel. A lighted camp lantern having been placed about 4ft. in front of the two tunnels, all the sliding doors were opened. After having been allowed to remain open for a definite period the sliding doors were closed and the boxes were allowed to remain *in situ* till next morning when they were carefully opened and examined. This arrangement was used on 12 occasions with the following results:—

TABLE I.

	1	2	3	4	5	6	7	8	9	10	11	12
	2h.	1½h.	1h.	½h.	20m.	15m.	10m.	10m.	10m.	5m.	5m.	5m.
Number of mosquitoes in Lighted box B ..	10	7	12	5	9	8	6	9	13	5	7	9
Dark box B (control) ..	0	0	0	0	0	0	0	0	0	0	0	0

In each case a number of mosquitoes, varying in number from 20 to 30, was placed in each of the two boxes C used in the experiment. The mosquitoes found in the lighted box B were usually females. Females containing blood did not appear to diffuse nearly so rapidly as those that had not fed.

As it was found that mosquitoes kept in the dark did not appear to diffuse to any great extent, the procedure was varied in a second series of experiments. For this series one tunnel 25 ft. long was arranged, closed at one end by a box type B and at the other by a box type C containing mosquitoes. The light-tight shutter over the mosquito-netting of box B was kept closed and all the sliding doors were then opened and allowed to remain open for 1 hour. At the end of this time the sliding doors were once more closed and box B was carefully examined to see if any mosquitoes had passed into it. On 8 occasions this was done without mosquitoes once passing into the darkened box B ; and on 7 other occasions when an inspection box D, 30 inches long and provided with sliding doors at each end was placed in the tunnel 5ft. from the mosquito box C, no mosquito was found to have passed into it during one hour when the sliding doors were kept open.

After replacing box B therefore the light-tight shutter was removed, and all the sliding doors with the exception of that into box B were opened. Light from a camp lantern was then allowed to be reflected into box B from the white-washed wall of the room, and the sliding door was quickly opened, the time being noted. As soon as the first mosquito was heard in box B the time was again noted., The times required for mosquitoes to diffuse the 25ft. from box C to B are given below :—

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
s.	s.	m. s.	s.	m. s.	s.	m. s.	m. s.	s.	s.	m. s.	m. s.	m. s.	s.	m. s.
45	25	1 20	65	1 35	46	1 30	1 10	38	49	1 45	1 30	1 15	55	1 5

The experiments described above have served to clear the ground for further work in the same direction. But though it will be necessary to amplify them considerably, both quantitatively and qualitatively the results already accomplished appear to show that mosquitoes are responsive to such stimuli as rays of light from artificial sources ; and that the use of artificial lights by man serves to attract mosquitoes to his immediate vicinity.

Incidentally it may be mentioned that the results of these experiments suggest an explanation of the recent observations of Fry and others in Bengal which show that in some malarious districts there, the growth of very dense vegetation in villages is associated with a much lower spleen index than is found in villages possessing a more moderate amount ; and affords further support to the view mentioned by Ross in the following passage on page 190 of his book on the Prevention of Malaria, that " It is generally held that a screen of trees shuts out malaria and mosquitoes this being one of King's original arguments in favour of the mosquito theory. Stephens and Christophers also accept this hypothesis. It is a likely one, but better proof is required."

The results of the experiment also afford a further argument in support of the more general use of properly designed mosquito-proof bungalows in malarious areas in the tropics. It is possible that the brilliantly lit up bungalows of Europeans often serve as a means of attracting anopheles from a wide area around them ; and in view of this it would appear advisable to urge the adoption of properly designed mosquito-proof houses, especially in the case of Europeans who may be compelled to live in known malarious localities.

KALA-AZAR IN ASSAM.

Precis of a Progress Report—February to September 1913.

BY

CAPTAIN F. PERCIVAL MACKIE, M.B., F.R.C.S., M.R.C.P., I.M.S.,

On special duty for the investigation of Kala-Azar.

The report is divided into three parts :—

(*a*) Epidemiological.
(*b*) Clinical.
(*c*) Experimental.

Epidemiological.

Curves have been prepared to shew the rise and fall of the epidemic from the year 1891 till the present date, and also that due to " fevers " other than *kala-azar*.

These shew that there has been a very slight increase during the last three or four years, though scarcely enough to confirm the belief of the villagers that there has been a distinct recrudescence of the disease during the recent years.

Maps have been prepared to shew the present distribution of the disease throughout the district.

A house-to-house survey of the township of Nowgong was carried out and this involved visits to about 900 houses and dealt with 4,778 persons. Amongst these only 27 positive cases were found and 21 suspicious cases, whilst 64 deaths from this disease were reported to have occurred during the last three years.

On analysing the 273 cases which came under observation, no evidence was obtained which threw any light on the question of seasonal prevalence nor on the effect of occupation.

The age distribution was however very interesting for half the cases occurred between the years 6—10 and 81·0 per cent. were in the first fifteen years of life.

The prevalence of malarial fever has been noted and " malarial villages " as distinct from " *kala-azar* villages " have been examined, and others also where the two diseases overlapped.

The former are generally near the foot hills, whereas kala-azar is more common in the open country and in villages in the vicinity of rivers or watercourses. It is in the latter places, however, that human intercourse is more active and the population is thickest.

A spleen census amongst 573 children in Nowgong town only revealed the small number of 3·5 per cent. with enlargement of that organ.

The people themselves have a very clear idea of the main features of *kala-azar*, but there is no prevalent theory as to its mode of spread.

Sexual intercourse as I am informed begins very early amongst children, but not until the maximum in age distribution has passed, and there is no good evidence that this channel of infection is a probable one. The writer found no evidence to associate *kala-azar* with a house infection as distinguished from a personal one and was of opinion that the main point of epidemiological interest in the disease is its dependence upon *close personal contact.*

The meteorological conditions of Nowgong have been studied and continuous thermographic records have been taken over the whole period.

Clinical Observations.

This part of the report deals with the records of 273 cases which were divided up, on clinical grounds, into " positive," " probable," " suspicious," and " doubtful."

The exclusion of the last group reduced the number to 205 and upon these the analysis was made.

These clinical observations were made on the usual lines and do not lend themselves to further consideration here.

Stress may, however, be laid on the irritability of the heart in *kala-azar*, for it is shewn that in a series of 117 cases only 6·7 per cent. had a heart beat of under 100 per minute whilst in 67·0 per cent. it was over 120 per minute.

Cutaneous *Leishmaniasis* was carefully searched for, but was not seen, though skin changes of other sorts were common.

An itch-like condition was present in 19 per cent. out of a total of 120 cases, but the itch-mite was not found.

Hæmorrhages from mucous membranes were common and bowel complaints including so-called " dysentery " were almost always present at some stage of the disease.

Treatment was attempted with vaccines of pneumococci and streptococci in an attempt to raise the leucocyte wave, but in this it was unsuccessful.

Salvarsan was tried in a few cases also without success.

Intestinal antiseptics were found to have some influence in reducing the fever and improving the general condition.

The only prognostic sign of real value is the rise or fall in weight.

This part of the report closes with the description of a few " Noteworthy cases," a series of charts shewing the degrees of visceral enlargement, the results of a series of blood counts and finally a selection of photographs of living cases and of the surroundings under which they live.

Experimental Work.

In a total of 433 examinations of the peripheral blood the specific parasites were found in 11 per cent., but excluding the "doubtful " cases, that is in the first three clinical classes 21 per cent. shewed *Leishmania.*

Spleen puncture was carried out in 60 cases and no ill-effect was noticed.

Some observations were recorded on the minute structure of the parasite and the writer emphasises the difference between those undergoing multiplication in a mass of cytoplasm which is derived from the activity of the parasite itself from that where inclusion has been brought about by the defensive action of the host's cells.

He is not inclined to believe that the significance of the parasite in the blood stream is as great as some would believe and raises the question whether under these circumstances *Leishmania* are not in a process of devolution, or whether it is not merely a provision for bringing about visceral dissemination.

To prove or disprove this he urges the necessity for further attempts to cultivate the parasite from the peripheral blood and to transmit the disease to animals in this vehicle.

Malarial parasites were found in the peripheral blood in 15 out of 217 cases that is, in 6·8 per cent., and the three types of parasite were each found on five occasions.

A summary of 49 animal experiments is given, of which 7 were positive (monkeys, flying-foxes and mice), and 25 negative, whilst the rest are still under observation.

The disease has been transmitted to a bazaar dog by the peritoneal route.

Fly papers were laid down in *kala-azar* houses on a total of 6,672 days, but the insect catch was disappointing and gave no clue.

Bodies resembling flagellates were found in about a third of the sand-flies (Phlebotomus sp.) examined.

The dissection of mosquitoes, fleas, and other insects proved negative and ankylostomes recovered from *kala-azar* patients likewise contained nothing of interest.

Insects and leeches fed on persons whose blood contained parasites of *kala-azar* proved in all cases to be negative on dissection.

The dissection of 469 bed bugs, all of which were caught in the bedding of persons proved to be suffering from the disease, proved to be negative on dissection and the gut contents of 209 bugs caught under these circumstances have failed so far to produce any disease in the monkey into whose tissues they were injected.

Ninety-three dogs caught in *kala-azar* villages have been examined and the spleen and bone-marrow have not shewn any visible infection. The bone-marrow of a number of these has been injected into monkeys, flying-foxes and a dog, but at the time of writing these animals are healthy.

This portion of the report concludes with an account of the examination of large numbers of edible fish from the River Kallung and a reference to the fact that in two cases out of about 40 examined, bodies resembling *Leishmania* have been observed in the stools of *kala-azar* patients.

Further observations on most of the above lines are being carried on in different parts of Assam.

THE BEARING OF ASSAM TEA GARDEN EXPERIENCE ON THE PROBLEM OF THE ETIOLOGY OF KALA-AZAR.

BY

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NEARLY seventeen years have elapsed since I recorded in my report on kala-azar the evidence which led me to the conclusion that the infection is essentially a house or site one, and recommended certain segregation measures for combating the disease. During all this time my friend, Dr. Dodds Price, has carried out these measures on a number of tea gardens in the Nowgong district, with such striking and uniform success as to leave no possible doubt that this terrible disease can be completely controlled, and he has thereby saved the tea industry of the district from very great loss, if not complete ruin. We have recently worked out together the available data, which we are recording in detail elsewhere, but they have such a direct bearing on the difficult, and still incompletely solved, problem of the etiology of the disease, that it will be worth while to briefly review the main facts in connection with the subject. I wish at the outset to emphasize the fact that Dr. Dodds Price has been in continuous charge of all the Nowgong tea gardens for sixteen years, and most of them for twenty years, during which time he has only occasionally been on leave for a few months. As on tea gardens he has had the unique advantage of being able to follow up over two thousand cases from first to last, and as, in addition to the year I worked in the Nowgong district in 1896-97, I have three times spent several weeks with him working at kala-azar, I can vouch for the accuracy of the data referred to. In fact, it is only under such favourable conditions that it is possible to obtain so many reliable facts concerning the spread of the disease.

The nature of the segregation measures adopted on the Tea Gardens.—I had the good fortune to carry out my original inquiry when the epidemic of kala-azar was at its height. In order to study the mode of extension of the disease I tramped 150 miles from village to village mainly where the disease was spreading in the Mangaldai district. Most striking evidence was thus obtained that the disease nearly always first broke out in that house of a village in which a kala-azar patient had come to reside from a previously infected place. Before I went to Assam, Dodds Price had recognised the communicability of the disease, and had arranged in 1895 to place 150 out of 200 freshly imported coolies into newly constructed lines, the remaining 50 for want of room having to be placed in the old infected ones. On working out the results two years later we found that no case of kala-azar had occurred among the 150 in the new lines, but 16 per cent. of those sent to the old lines were already dead of the disease. This decided us to try if the disease could be stamped out of already infected lines by segregation methods, which were carried out as follows. As at that time—and the same holds true to a considerable extent to the present day—it was impossible to detect the disease by clinical means in its early stages, we decided to move out of the infected lines into new ones only those households who were completely free from the disease, the remainder being kept in the old lines, and no new coolies admitted to them, the vacated houses being destroyed. The first community to be thus tackled was so severely infected that only 96 persons out of 240 were free from infection in their houses and so could be moved. They were placed in a new set of similar huts only 400 yards from the infected lines, and newly imported coolies added to them until they numbered 800. To this day, not that is for 16 years, not a single case of kala-azar has occurred among them. Yet of those with infection in their houses who had to be left behind not less that 80 per cent. died of kala-azar within the next few years, while a contiguous line of 60 old acclimatized coolies, who refused to be moved, also became infected, and nearly all of them perished of the disease, which thus eventually died out of the spot.

The results obtained on the Nowgong Tea Gardens during the last sixteen years by segregation measures.—In the paper referred to we have tabulated the results obtained on ten consecutive tea gardens where these measures have been carried out by Dodds Price at various periods from 1897 to 1908. The total working population at the present day—and there has been no material variation during the period under review—amounts to 6,727, or, if young children are also included, to upwards of 8,000 souls. With one exception of two and a half years, eight years is the shortest time which has elapsed since the lines were moved, yet in no single instance has a kala-azar case occurred in the new lines, the disease having been thus completely stamped out of a number of gardens where it was causing most serious loss of life and money. As the measures were equally successful whenever carried out from 1897 to 1908, their success cannot be attributed to the decline of the disease in the district, especially as the last outbreak in 1908 was very nearly as deadly on the tea gardens as the earlier ones.

As actual figures are more striking than verbal descriptions, the following example, abbreviated from the paper referred to, may be given.

Outbreak on the Amluckie Estate.—Kala-azar began in 1896, increased in 1897, and caused a high mortality in 1898, but the exact figures are not available for those years. rom 1899 onwards accurate figures are on records which were as follows:—

Year.	*Working population.*	*Total deaths.*	*Kala-azar deaths.*	*Remarks.*
1899	1,074	167	138	Before the lines were moved.
1900	1,056	146	112	
	Movement of lines commenced.			
1901	1,026	32	9	
1902	975	35	10	All in old lines, none in new lines.
1903	918	33	15	
1904	896	28	13	
1905-12			*Nil.*	

It will be seen from the above table that the mortality from kala-azar alone during the two years before the lines were moved was no less than 128 and 106 per mille, respectively. Yet it fell the next year to but 9 per mille, and in four years was completely and permanently stamped out with comparatively trifling further loss. The results have been equally favourable in the other nine instances.

Control example showing the indefinite continuation of the disease in infected lines as long as freshly imported coolies are admitted to them.—I have mentioned Dodds Price's first segregation of freshly imported coolies in new lines in 1895, and the high mortality of those who went into the old infected lines. There are still, eighteen years later, a number of coolies living in the old infected lines, and the disease to this day exacts its yearly toll of lives. At least 345 deaths from kala-azar took place in them up to March 1908, but exact details are not available owing to the records then having been burnt with the hospital. Since that time the yearly kala-azar deaths have been as follows:—

1908	1909	1910	1911	1912	1913	Total.	Remaining under treatment.
14	11	11	10	8	9	63	10

The only other Nowgong tea garden on which the segregation measures have not been fully carried out is that of the Salona. Here again the disease has continued year by year in the old lines, although certain partial measures have had a marked effect in reducing the incident of the disease, as the following figures from table in Dodds Price's paper giving the yearly deaths for seventeen years will show.

Before 1897, when the garden came under Dodds Price's care, there had been about 80 deaths from kala-azar. In 1897 and 1898 the kala-azar deaths were 74 and 75, respectively. As the two infected lines contained a population of 1,500 workers, I suggested a trial of moving out all the infected persons and their households into a kala-azar camp, which was now carried out, commencing late in 1897. In 1899 and 1900 the deaths in the infected lines fell to 12 and 2, but up to the end of 1900 no less than 150 deaths took place in the kala-azar camp, which was broken up at the end of 1900. During the next four years the cases slowly increased again in the old lines from 5 in 1901 to 24 in 1904, during which year I revisited the garden. Two new measures were now adopted. In 1905 a new coolie line was started into which newly imported workers were placed, and which now has a working population of 600. Very few cases of kala-azar have occurred in this line during the past eight years, and these were due to want of care on the part of the manager in admitting coolies from the infected lines in spite of Dodds Price's warnings.

At this time, as a result of my discovery of the flagellate stage of the parasite, and of the necessity of sterility for its development, and that neutrality or even slight acidity was most favourable to copious growth, I had come to the conclusion that the homely bed-bug was the most likely carrier of the disease. I was strongly confirmed in that opinion by Dodds Price's experience to the effect that every

European planter who got kala-azar had cohabited with a native woman who was actually suffering from the disease, and by the success which had already attended the segregation measures described above, although the distance the lines had been moved was too short to prevent infection being carried by flying insects, which thus excluded mosquito. I therefore suggested an attempt to destroy the bed-bugs in the infected houses as a preventative measure, which was carried out by Dodds Price as I have previously recorded. Only the worst infected line was thus dealt with, the other being left as a control. During the following six years from 1905 to 1910 only nine cases of kala-azar occurred in the disinfected line among 850 workers, against 17 in the control line of only 650 working population, which is greatly in favour of the bug-disinfected houses, in which no fresh case occurred for several years.

During the last three years from 1911 to 1913 there has been a distinct recrudescence of kala-azar at Salona, the deaths having numbered 13, 15 and 24, respectively, against an average of only 4·3 in the previous six years. This increase has coincided with the renewed admission to the old lines of freshly imported coolies owing to the new lines having become full. It is thus abundantly clear from this and the Rangamati instance, that the disease tends to continue indefinitely as long as fresh fuel, in the form of new coolies, is added yearly to the old infected lines. These lines are now to be dealt with by the segregation measures which have proved uniformly successful in the ten lines in which they have so far been carried out, and there can be little doubt that they will be as effective here as hitherto, and that the dread kala-azar will shortly be finally eradicated from the Nowgong tea gardens as the result of Dodds Price's unremitting labours of the past twenty years. I think it would be difficult to find a more successful example of the eradication of such a deadly disease in a large and scattered working population in the whole range of preventative medicine, due to a simple method based on careful epidemiological observations. Not the least remarkable feature of this successful campaign is that it was evolved and effectively carried out at a time when we were completely ignorant of the nature of kala-azar, and indeed before the mode of infection of malaria was established. I therefore venture to think that the facts established during the last twenty years' careful observations of Dodds Price on the Nowgong tea gardens are worthy of careful study in relation to the vexed problem of the precise mode of infection of kala-azar, as no theory which will not account for this mass of accurate data can possibly be accepted.

The bearing of the foregoing data on the etiology of kala-azar.—After discovering the development of the flagellate stage of the parasite of kala-azar and carefully studying the conditions most favourable to it, I suggested the bed-bug as the most likely carrier of the infection for the reasons already mentioned among others. The earlier finding of the parasite in the peripheral blood in small numbers and intermittently by Donovan, Christophers and others, had also paved the way for this theory. I had earlier, when looking for plague bacilli in bed-bugs, found that the contents of their stomachs were frequently sterile as regards bacteria, and also slightly acid, even after a feed of human blood. It was also known that water, even a little moisture on a slide, at once destroys the organism. This, together with the necessity of sterility of the saline citrate culture medium, makes it almost inconceivable that the parasite can live in the outside world except within some insect host. The fact already recorded, that 300 to 400 yards is sufficient distance to secure permanent immunity of coolie lines, as long as no one from the infected lines is allowed to go into the healthy ones, excludes any flying insect, such as the mosquito, and leaves the homely bed-bug as the most likely remaining insect carrier. The rarity of the disease among better class Europeans, save when they have been cohabiting with infected native women, is also readily explainable on the bed-bug theory. Yet again, the incidence of the disease in Calcutta, mainly among Indians and the poorer Eurasians, who live in greatly overcrowded houses on account of the high rents, is easily understood. In short, I know of no epidemiological fact which cannot be explained on the theory of infection through the ubiquitous bed-bug, unless it be argued that the disease ought to be more common even than it is if the bed-bug can readily convey the infection.

Moreover, Dodds Price's experience on tea gardens enables water and diet to be absolutely excluded from the consideration, for reasons given in our joint paper. In a number of instances there was no change in the water-supply for a considerable time after the lines were moved, the inhabitants of both the old and the new lines using the well of the infected lines. In no case was there any change in diet. Yet the segregation measure was always successful in eradicating the disease.

Will the occasional development of the parasite in the bed-bug obtained by Patton account for the known epidemiological facts regarding kala-azar on tea gardens?—Early in 1905 I obtained the development of the flagellate stage of the parasite in sterile mixtures in capillary tubes of equal parts of infected spleen blood and the contents of bed-bugs which had fed on human beings. In the spring of that year, during three weeks' leave to Assam, I failed to find any development in 200 bed-bugs fed

on kala-azar patients, but I recognised at the time that the number of experiments was far too few to be of much importance ; more leisure is necessary for such work than my official duties will allow. I was therefore relieved when Captain W. S. Patton, I.M.S., was put on special duty to investigate the subject, with the result of obtaining in 1907 occasional development of the flagellate stage in these insects fed on the blood of kala-azar patients showing the parasite in their peripheral blood. His more recent observations, showing that if the insects are given a second feed of human blood any development already taking place is checked, partly explains the infrequency of his positive results.

One question now remains to be answered.—Is the occasional development of the parasite in the bed-bug obtained by Patton sufficient to explain the known epidemiological facts of kala-azar ? In the second edition of my work on " Fevers in the Tropics," I wrote :—" The infrequency with which he (Patton) obtained developmental forms of the Leishman-Donovan bodies in bed-bugs fed on cases of kala-azar showing numerous parasites in their peripheral blood, is remarkable, and leaves some doubt as to whether this is the common and only mode of infection." As a result of my recent renewed studies with Dodds Price of the epidemiology of kala-azar on tea gardens, I have been led to modify that opinion. In the paper with Dodds Price in discussing this point we wrote as follows :—" It has been objected that Patton has only succeeded in obtaining a very few such positive results in a large series of experiments. If we consider for a moment the epidemiological facts, this does not appear to us to be such a serious obstacle to the acceptance of the theory as might at first sight appear. It will be evident from the data in the first portion of this paper, that a very considerable proportion of persons may live for a number of years in the same coolie lines, or even, as often happened, in the same house, as other persons infected with kala-azar, and yet for long escape infection. The further fact, that if people go on living long enough in such infected houses the great majority of them do eventually contract the disease, so that after a number of years almost the entire population of a set of huts may die of kala-azar, appears to show that the slowness of the infection is not due to lack of susceptibility to the disease. We know that in the same lines every soul is likely to contract malaria over and over again within the same period of time." (Yet only a very minute percentage of the carrying species of mosquito may be found infected.) " We can also testify from personal experience that bed-bugs can be collected by the score from every coolie hut. It would appear from these facts that, if even one bed-bug in a hundred was capable of carrying the infection of kala-azar, every person in an infected house would rapidly develop the disease. Moreover, the rarity and scantiness of the parasites in the peripheral blood will alone account for much of the difficulty in feeding experiments. It would be quite sufficient for bed-bugs only very rarely to become capable of conveying the infection, under conditions and exact knowledge of which is not yet available, to enable them to be efficient carriers of the disease." The bed-bug theory therefore best accounts for all the known facts, and the good effect obtained by disinfecting operations by means of fumigating with sulphur and the use of perchloride solution against these insects in the Salona lines also lends further support to it.

The uniform success of the Nowgong segregation measures proves that the recommendations of my original report, of measures to encourage the healthy persons to move out of infected villages to new sites, were perfectly sound, although they are less easy to carry out than on tea gardens under European control. The frequency with which successive cases of kala-azar occur to poor Eurasian families, especially among the children, as I have repeatedly pointed out, renders it advisable to carry out disinfection operations, especially directed against bed-bugs, as by sulphur fumigation, of the rooms which such patients have occupied. Every encouragement should be given to kala-azar patients to go into hosipital, both in order to lessen the danger of their infecting others, and to ensure prolonged and careful treatment and also study of the disease, with a view to finding a better treatment. A special ward for kala-azar either in the Medical College or in a hospital for tropical diseases, would be a great boon.

REPORT ON THE PROGRESS OF THE KALA-AZAR INVESTIGATION DURING THE SEASON 1912-13.

BY

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INTRODUCTORY.

THIS investigation which was undertaken with the object of ascertaining the number and extent of the existing endemic foci of kala-azar in Assam has been in progress since October 1912. Its aim and scope was described in a paper read before the Conference at Madras.

Subsequent to the inception of this provincial survey, the arrival of Captain Mackie, I.M.S., in the province, on behalf of the Government of India, enabled us to devote our energies solely to the practical public health aspect of the case and to leave the problems of research entirely in his hands. We endeavoured to assist his work by communicating to him any important information which came to light and by endeavouring to procure for him information which he required.

Although this survey is incomplete as to the Dhubri sub-division and parts of the Kamrup district, yet it is believed that no endemic foci of any magnitude exist in these areas, and this interim report probably gives a substantially correct estimate of the extent of the infection. The survey will, however, be continued as soon as work can be commenced after the Puja holidays.

Two Assistant Surgeons aided me in the supervision of the survey, and fourteen Sub-Assistant Surgeons were at work from October to March.

The Sub-Assistant Surgeons were given a preliminary training by my Assistant in the method upon which the survey was to be carried out, and on the clinical signs and symptoms of the disease. Sub-Assistant Surgeons were provided with a small stock of drugs and dressings to enable them to treat minor ailments and gain the confidence of the people.

In company with Captain Mackie, I.M.S., I visited the infected areas in Golaghat in which preventive measures are in progress, from thence we marched down the South Trunk Road to Nowgong, visiting areas reported to be infected in that district. Owing to the considerable number of cases discovered in Nowgong district, Captain Mackie resolved to settle in Nowgong and conduct his research work with Nowgong town as his headquarters.

All the areas reported to be infected and a considerable proportion of the infected villages, were visited by me in the course of the cold weather, and the existence of infection verified in all these areas by splenic puncture of selected cases. Reports as to the absence of infection were also verified in a large number of villages.

During the rains I toured by launch through the Sylhet district, and visited the infected areas, and verified as far as possible the absence of infection in areas reported to be free. As the result of my observations, I put forward this report with a fair degree of confidence that it contains a good general estimate of the extent of the endemic foci of kala-azar in the province.

In supervising the work of my staff, my efforts were directed towards verifying their reports of infection of villages, or of absence of infection.

For this purpose I did not attempt to perform a large number of splenic punctures with the object of diagnosing every suspicious case seen, lest, on account of the unpopularity of the operation, I might prejudice the success of future preventive measures.

My aim was to satisfy myself of the presence of kala-azar infection and to perform a sufficient number of splenic punctures to establish the presence of the disease.

In doing so the method adopted was as follows:—

An all-glass hypodermic syringe, with several needles, was sterilised before going out for the day. A bottle of tinct. iodi. and one of liquid carbolic acid was carried, and a box of carefully cleansed slides.

When the confidence of the villagers had been obtained, in the course of palpation of spleens with the patients recumbent, tinct. iodi. was applied to the skin over the spleens of all examined. In a selected case with a hard spleen and no evidence of excessive blood deterioration, a drop of carbolic acid was also rubbed into the skin over the area for puncture. When the skin over this area had become somewhat numb, a sterilised needle, carefully concealed in the hollow of the left hand, was rapidly plunged into the spleen and the patient's attention attracted elsewhere, while my assistant rapidly fitted the syringe to the needle, withdrew a drop or two of fluid and made the films. In most cases the puncture was thus accomplished without the patient being aware of any unusual proceeding. The patient was always cautioned to lie down for the rest of the day, and a dose of calcium chloride administered before leaving.

In this way punctures were performed with as little fuss as possible, and no bad results occurred.

I am indebted to Captain Mackie for the details of this tactful technique of puncture.

I append a list of places in which splenic punctures were performed and Leishmania parasites obtained. In addition to the splenic punctures, a large number of peripheral blood films were made from suspicious cases with the object of eliminating, as far as possible, the confusion with malaria. In only a few of these suspicious cases were malarial parasites found after a search of a minimum duration of 15 minutes. In one peripheral blood film, a single Leishmania-Donovan body was found in a large mononuclear.

Although nothing but a positive result from splenic puncture is of any certain value for the diagnosis of an early case of kala-azar, I found the following observations of some assistance in arriving at a conclusion without performing splenic puncture :—

I. In about 50% of the cases (see table), a previous history of deaths from kala-azar in the house could be elicited.

A positive family history is, therefore, a very strong point in settling a doubtful diagnosis.

II. In visiting a village reported to be infected, out of three or four cases seen, one was commonly recognisable on clinical grounds. The presumption would then be strongly in favour of a diagnosis of kala-azar in the doubtful cases.

III. While malaria is very hard to differentiate from early kala-azar on clinical grounds, I noted that if towards the end of the cold weather, one found a family of two or three children suffering from enlarged spleen with a history of infection during the preceding hot weather, and with a history of improvement of health in all cases, instead of deterioration, one might assume that the infection was malaria and not kala-azar, in which disease the general tendency is towards death and not towards recovery.

In some doubtful cases of this nature, I found malarial parasites in the finger blood.

Other diseases which I found to be confounded with kala-azar are :—

I. Chronic dysentery.

This is often the final stage in a kala-azar infection, as of other diseases, and hence the confusion.

II. Ovarian cyst.

One such case was erroneously reported as kala-azar.

III. Splenic leuchæmia.

One such case came to my notice in the person of a male adult in the Nowgong district, who showed all the gross clinical signs of kala-azar emaciation, muddy complexion, anæmia, enlarged spleen and liver.

I noted some degree of dyspnœa at the time of examining him, a symptom not usually associated with kala-azar and, on examining a film of his blood, found the field crowded with white blood cells.

Sub-Assistant Surgeons' Reports.—Appendix I.

The following figures and observations are available from the reports of the Sub-Assistant Surgeons and my own observations.

Sex incidence.—Out of 729 cases seen, 498 or 68·3% were males and 231 or 31·6% were females. While there is always a tendency to conceal the occurrence of the disease among native females, the age incidence table shows that nearly $\frac{3}{4}$ of the cases seen occurred during the first three quinquinnia of life, and at ages during which concealment of disease among females is not likely to affect the results very markedly. It appears from these figures that there is possibly a higher incidence upon males, than upon females, which is curious, at ages when the habits of native children of both sexes are very similar; there is probably a fallacy in these figures, perhaps due to the greater timidity of female children.

Age incidence.—The figures show an increased incidence upon the age groups in the first four quinquinnia as compared with the figures given by Major Rogers in 'Fever in the Tropics' for the Assam Valley during the epidemic years 77·3% of the cases seen in this investigation were under 20 years of age, as against 50% in Major Rogers' report. It may be that the incidence of a less virulent type of the disease leads to its being confined within the limits of the age groups which are most susceptible to it. A further explanation of this special incidence may be found in the fact that a new and susceptible generation of children has sprung up since the disease in epidemic form first took its toll of life in the Assam Valley.

The age incidence seems to be approaching that seen in the kala-azar of the Mediterranan littoral.

Occupation.—88·7 of the cases seen belonged to persons whose occupation was that of agriculture. This gives no indication of the relative numerical incidence upon different occupations, as the majority of the inhabitants of the province are cultivators.

From what I saw, however, I have no reason to believe that there is any special incidence upon classes of special habits of life, such as fishermen or traders, and I believe that the figure in question represents the fact that the bulk of those affected by the disease are agriculturalists.

Caste.—The figures showing the distribution by caste are not particularly informative, as they are calculated upon cases seen, and other things being equal, the most numerous castes will produce the largest number of cases, and only an analysis of the incidence in an infected area with different castes, living side by side could produce figures of any value. The high incidence among Kacharis in Mangaldai, in the Gauhati sub-division and in Goalpara, is worthy of note.

Number of cases in which a previous history of kala-azar in the family was obtained.

This shows a total of 52·1% and varies according to different observers from 86% to 21·4%.

It is curious that in the returns from the Western Circle of Nowgong district, which were obtained by a Sub-Assistant Surgeon who is an energetic and reliable worker, the number of infected families showing a previous history of disease in the family was 37·3% as against 65·4% in Mangaldai and 86% in Kamrup. According to my observations, the disease appears to be most active in Western Nowgong and the difference in figures may possibly mean a more spreading type of disease.

House surroundings.—60·8% of the infected houses are shown as being situated in light jungle. This is, of course, typical of Assam conditions.

30·8% are situated near running water and 8·6% near tanks.

Drinking water.—42·6% get water from wells, 19·8% from tanks, and 33·3% from running water.

Domestic animals.—64·2% of infected families possess cattle, 50·4% keep fowls, 43·9% keep dogs, 39% cats, then follow pigs, goats and pigeons in a decreasing ratio. The comparatively small number of infected families which keep dogs seems to indicate that the dog is not concerned with the propagation of the disease in Assam, and this observation is in line with the research work of Donovan and Patton in Madras.

Evidence of vital statistics and increase or decrease.

In the case of all the infected villages which I visited I enquired into the past history of the disease in that village and in nearly all cases the answers were practically the same, *viz.*, that a large number of deaths had occurred during the earthquake epidemic, since when practically no cases had occurred until the last two years. There is undoubtedly a consensus of opinion particularly in the Nowgong district to the effect that in certain areas the disease is showing increased activity of late years.

To decide as to whether there is any basis of truth in these statements, I have prepared a statistical statement of deaths from kala-azar year by year for the last 20 years, district by district, and also circle by circle, where such records are available in the office of the Sanitary Commissioner. During the 20 years under review the totals for the Assam Valley districts seem to have reached their lowest levels in the years 1908 and 1909, thereafter Goalpara shows an increase, the Garo Hills and Kamrup remain about the same level, Darrang shows a decrease, Nowgong an increase, Sibsagar a few cases, and Lakhimpur a few cases upon tea estates. There is no important change, therefore, in the general district mortality from kala-azar.

Scrutinizing the recent district returns in detail, in Goalpara, the Dudnai thana shows a marked increase. In Kamrup no substantial variation of increase or decrease has occurred in the last seven years. In Darrang, no material alteration has occurred, but the reported death-rate in the thanas of Mangaldai, Kalaigaon and Paneri is maintained at a uniformly high level.

The district of Nowgong shows a decided tendency to increase in the last two years. The mortality is double that of the years 1908 and 1909 when the lowest point since the epidemic was reached.

Sibsagar shows a sudden increase in the Golaghat thana in the year 1911, when a hitherto neglected centre of kala-azar infection was recognised and deaths formerly registered as fever deaths were properly recorded. Lakhimpur shows no deaths from kala-azar in 1912.

As the result of my observations, I am inclined to think that the popular ability to diagnose kala-azar is tolerably reliable. The people know the symptoms and appearance of the disease only too well.

The reason why the disease should have persisted in certain areas, and should have more or less died out of others in which during the epidemic years it was equally active, is a curious epidemiological fact that requires explanation. There is no apparent reason why this should be so, and the fact that determines it may be one of the factors in the causation of the disease at present unknown, or unproved. Possibly further research in these areas may discover this factor.

The extent to which such deaths appear in the returns may be questioned, but the error probably does not vary much from year to year.

Although the statistics do not show any disquieting increase in the number of deaths, I am inclined to think that the opinion of the villagers is correct, and that there is a tendency to an increase of the activity of the disease in certain areas. If village statistics were available, this might be demonstrated by statistical methods, but these records are not to be had in our office. A point to be taken into account when considering statistical returns with regard to kala-azar is the fact that it is a slow disease, and in the form in which we see it at present, usually takes 1 year to 1½ years to kill its victims.

Any sudden rise in the number of infections will not affect the mortality appreciably until after the lapse of a year or more.

All that can be deduced from these figures is the general observation that we have not at present any statistical evidence of a general increased mortality from kala-azar.

District Returns.—Appendices II & III.

Garo Hills.—In so far as it was possible to survey this very jungly tract we have discovered only 8 villages suspected to be infected, all but two contain only one case, and thus in all, only ten probable cases were discovered.

Other enquiries, made by me, tend to show that there is very little kala-azar in the Garo Hills, although possibly a few isolated villages here and there still suffer from the infection.

In the appendix to the Assam Sanitary Report of 1882 it is noted as follows :—

" As far back as 1869, the attention of administrative officers in Assam became directed to a peculiar disorder called kala-azar, the ravages of which decimated, and in some instances almost depopulated, numerous districts in the Garo Hills. The disease is most intense where the low, densely-wooded Garo Hills join on to the low-lying Central Assam plain, a position par excellence the most favourable for malarial developments. The Garos give definite accounts of the invasion of their villages by this epidemic at periods varying from 3 to 30 years previously."

The disease was known among the Garos as the ' Sirkari ' disease, owing to its appearance being contemporaneous with that of British rule. Gruesome tales are told of how on account of its recognised infectious character, infected persons were expelled from villages, and, stupefied with drink, were burnt alive.

The disease subsequently spread downwards into the Terai country at foot of the hills and thence into the Goalpara district.

The almost complete disappearance of the disease except in a scattered sporadic form is noteworthy when the past records of the disease in this district are examined, and it is interesting to note that in the tract of country in which it first appeared within the jurisdiction of Assam Administration, it is now almost absent.

Can a racial immunity have been acquired in the 50—60 years which seem to have elapsed since its first appearance ?

Goalpara.—In Dhubri sub-division, only eleven infected villages have been discovered, some of which are reported on doubtful evidence. This sub-division has been badly surveyed and to complete the investigation further work is being done in it. From the mortality returns it does not appear probable that any extensive infection will be discovered.

In the Goalpara sub-division, the Dudnai thana contains 25 infected villages and Goalpara thana six. The centre of the infection is in Terai country situated at the foot of the Garo Hills in a comparatively circumscribed area.

Past History.—It appears from the past records of the disease that during the decade 1881-1891 when this district suffered from the epidemic, the sadr sub-division was little affected, but that the Goalpara sub-division lost something like 18%

of its population during this decade. In 1883 the incidence was greatest in the portion of Goalpara at the foot of the Garo Hills, relief works were started in 1883 and 4,919 cases were treated.

The agglutination of the endemic disease round this Damra centre is curious. The Lakhipur thana to the west contains only one infected village, while to the east there are no connecting links with the endemic centres in Kamrup.

Kamrup.—Sixty-one villages are reported to be infected in the Gauhati sub-division, the list is probably not quite complete, but is approximately correct.

The tendency to cling to villages in Terai country is particularly noticeable in this sub-division and is better shown upon a large scale map which indicates the presence of low foot hills.

Gauhati town contains some cases, and in its neighbourhood are some infected villages. On the north bank the large Barpeta sub-division contains 8 infected villages and none badly infected. The Rangiya area, already reported on by Captain Harnett and visited by Captain Mackie, is an area in which the disease appears to be tending towards extinction rather than towards increased activity.

Past History.—In the epidemic, the incidence was chiefly upon the south bank. It is interesting to note that Barpeta, which suffered severely, is now almost free.

With reference to these two districts, one would feel inclined to assume that the disease is associated with the proximity of low jungle clad hills rising out of rice land. This observation is not however borne out in other districts.

Darrang District.—Tezpore sub-division. There are only two villages which are certainly infected, and 14 which contain one or two very doubtful cases. The infection has practically died out of the Tezpore sub-division.

Past History.—I am unable to trace any records as to the past infection of Tezpore sub-division, except from the statistics quoted, which showed a small kala-azar mortality in 1896.

In Daogaonpukuri, which is one of the two undoubtedly infected villages, the people state that during the epidemic of kala-azar the victims died almost as suddenly as in a cholera epidemic.

The general opinion in the district is that kala-azar has almost disappeared, the people questioned the Sub-Assistant Surgeon closely as to why Government were troubling about it now when it has disappeared instead of when it was rife. The Sub-Assistant Surgeon, who surveyed this sub-division, notes that the people informed him that during the time of the epidemic, bed-bugs were unusually prevalent. I had not suggested any question on these lines, and the statement was not prompted by a leading question. I simply record the observation without further comment.

In my opinion, the sub-division is practically free from the disease except for a few chronic and sporadic cases.

Nowgong.—In this district 86 infected villages were discovered by my staff.

Some additional information is also available through the kindness of Captain Mackie who has been conducting research work in this district and has been able to carry on my preliminary investigation in greater detail. A number of additional villages have been reported to be infected in returns submitted by mauzadars. I have excluded these from my list of infected villages, to which I have however added seven villages considered by Captain Mackie to contain the infection.

Although the actual number of infected villages in Nowgong is less than in Mangaldai, the type of case seen is undoubtedly more acute and the number of cases per village is greater and comparatively few villages contain only one single doubtful case. More cases of an unmistakeable character could be discovered in infected villages in Nowgong than elsewhere. I base this statement on my own observations made in the course of my visits to infected villages. It would not be legitimate to attempt to show a comparison of the number of cases discovered per village in the different districts as a measure of comparative intensity of infection, as the observations were made by different observers.

The incidence of the infection is greatest upon the more populous area of country on the banks of Kallang and the eastern portion of the district is the most seriously infected. The western portion is comparatively free.

Past History.—The district was attacked in 1889, and suffered the most of all the districts in Assam. In 1894 the disease reached its furthest limit at Silghat and Joklabandha.

It is noteworthy that the description of the areas affected as given by Major Leonard Rogers in his report, is almost an exact description of the distribution of the disease as it exists to-day.

No description of the condition of affairs in the Nowgong district is complete without a mention of the somewhat disturbing fact that the people themselves are convinced that the disease has begun to increase of late years. I have dealt with this observation in my remarks regarding the vital statistical returns which seem to indicate that this popular opinion has some basis in fact.

Sibsagar.—The infected area in this district was surveyed prior to the commencement of the general survey, but upon the same lines.

To complete the report upon the distribution of kala-azar in the Assam Valley, I include the following information gathered from my last inspection of the preventive operations we are conducting there.

Eight villages are infected in the Golaghat sub-division.

The infection is dying out of the village of Khumtai, in which it was first discovered, and is more active in the infected villages towards the east, in the Nahorani Mauza, on the banks of the Kakodanga river.

The preventive measures we have undertaken there are proving successful, but no relaxation of our grip of the disease, here on the margin of previously uninfected country, should be permitted.

Past History.—There is nothing in the records of the Sanitary Department to show that the disease had reached the Sibsagar district until 1911 when its presence was recognised. It had however almost certainly been imported many years previously. Any extensive importation of infection during the epidemic years had been prevented by measures of exclusion of infected immigrants.

Upper Assam Valley.—No kala-azar infection is believed to exist east of the Kakodanga river, in the Jorhat of Sibsagar sub-divisions or in the Lakhimpur district.

The medical and vaccination staff have been asked to exercise vigilance as to this and to bring to the notice of the Civil Surgeon and Sanitary Department any suspicious cases that may come to their notice.

This caution will be re-issued by circular at intervals, to make sure that it is not lost sight of.

No cases except 49 cases upon tea estates in Lakhimpur in 1910 and in 1911, have come to light, and we are probably justified in assuming that the Upper Valley is still free from infection.

My conclusions are as follows :—

In the following areas the disease exists in endemic form and shows activity in the district of Nowgong :—

1. In the Mangaldai sub-division.
2. In the Dudnai thana of Goalpara district.
3. In the Gauhati sub-division.

It exists in a few villages but in a quiescent state, in the Barpeta sub-division—

1. In Tezpur sub-division.
2. In Dhubri sub-division.
3. In Golaghat sub-division.

In the Nowgong district there is undoubtedly some activity in the disease, which is attacking the young, and susceptible population of children which has sprung up since the earthquake epidemic. European residents in the Nowgong district have noticed a large increase in the number of children in the Assamese village of late years. The activity of the disease is not confined to any particular centre but is widely spread throughout the eastern half of the district. The situation is more serious in Nowgong than elsewhere on account of the economic importance of the district, its proximity to the uninfected districts of the Upper Valley and the greater activity of the disease. In Mangaldai, the conditions are somewhat similar, but the activity is not so great.

In the Goalpara and Gauhati sub-divisions there is a fair amount of disease, but of a more chronic and less spreading type than in Nowgong. In Tezpur and Barpeta and Dhubri there are only a few sporadic cases scattered here and there, and there is no tendency to activity, or to agglutination of the disease round centres.

The Rangiya centre in Kamrup shows no signs of activity.

I have depicted in my map the areas which are infected in the Sylhet district. A preliminary survey of this district was carried out by the Civil Surgeon, Captain Scott, I.M.S., and the survey has been amplified and its results confirmed by my investigating staff.

Cases of kala-azar are to be found in villages round Chattak, Sunamgunge, Jaldhup and Nabigunge, but in these areas the disease is not nearly so active, nor are the infected persons so numerous, as in the infected areas in the Assam Valley. The remainder of the district is free from the disease, indeed it has died out in places in which it formerly existed. In my opinion kala-azar is of no practical importance in the morbidity of the Sylhet district and requires no special measures of observation or control.

Recommendations.—The following recommendations have been made to the Assam Administration. On account of the number of endemic centres we have discovered, and their widespread distribution, any attempt to meet the disease by measures similar to those we have put in force in Golaghat could only be done by a staff, and with an expenditure, comparable to that required by the Plague Department in the Punjab or United Provinces.

The indefinite nature of our knowledge as to the mode of the transmission of the disease, and the want of any remedy to cure it, would make it very difficult to frame a plan of campaign which would have sufficient certainty of success, and be sufficiently far removed from the experimental stage to justify the very large expenditure which operations on a large scale would involve.

Furthermore, it is not by any means certain that there is a definite probability of the disease spreading to areas other than those in which it now exists, and it may be that the present sign of activity in certain areas are only temporary exacerbations which may again abate. This we can only determine by watching the course of the disease. We should also endeavour to limit its spread from these areas and to prevent any diffusion of the infection into areas at present unaffected.

For the first purpose, that of watching the course of the disease, I propose that Sub-Assistant Surgeons should be put on duty to tour in the infected areas. Allowing a week to each village, then about 50 villages should be visited in the course of a year. On this basis and with due regard to the area to be covered, one man may be allotted to the Dudnai thana and adjacent infected areas in the Kamrup district, a second for the balance of the Kamrup district, a third for the infected areas in the Mangaldai sub-division, which, although it contains a large number of villages, may be covered by one man, as the infected villages are many of them very near each other.

A fourth and a fifth must be assigned to Nowgong, on account of the large area to be covered, and the large number of cases. A sixth should be put on duty in the Sibsagar district to supervise the more active measures of prevention which we propose to continue there on account of the proximity to uninfected territory, and to tour through uninfected country and keep us informed of the continued absence of infection. I propose that during the months of October and November and December, these men should first be employed in completing the survey of the Goalpara and Kamrup districts in which the survey is incomplete. Although I do not anticipate that any very extensively infected areas will be discovered, the survey would lose much of its interest and scientific value if it remained incomplete as to these areas.

The Sub-Assistant Surgeons should be provided with the complete equipment of travelling dispensaries and it should be their duty to tour in the infected area, visiting all villages in the area allotted to them, gaining the confidence of the people by treating their ailments, and submitting regular reports to the Sanitary Department. This organisation should be independent of the general scheme for travelling dispensaries and should be directly under the control of the Sanitary Department.

To get a good class of man for the appointment the scale of pay should be liberal and the appointment should be made for three years.

Under their supervision certain villages in these areas, which prove to be badly infected, might be encouraged to move to new sites, and practice the modified measures of segregation, with help from Government, as already carried out in Golaghat. In this way we can keep informed as to the increase or decrease of kala-azar in these areas, and afford the people some degree of help in their trouble.

At the same time, however, we must not forget to safeguard the interest of the unaffected population and measures for this purpose are required to prevent the possible spread of the disease.

Measures of Control.—It appears that the propagation of kala-azar is in this way:

An area gets infected by importation. The infection spreads and a panic is established. Infected families, who have lost one or two of their number and see others dying, decide to migrate elsewhere to an uninfected area. They do so, if unchecked, taking with them an infected person, or the seeds of the disease. This leads to the propagation of the disease in this area and the process then repeats itself.

The people themselves are well acquainted with this and will often refuse to allow an infected family to enter their village or to permit a member of an infected family to enter another by marriage. Petitions have been received by me and by my staff to have infected families removed from the proximity of others.

It is pretty generally acknowledged that the Upper Assam Valley was saved from infection because immigrants were refused admission to Golaghat during the epidemic.

It must be remembered that with the increase of railway communications, it is much easier for people to migrate now than formerly, and hence it is more easy to spread infection. To deal with this we should control migration from infected areas, and give villagers the right to refuse admission to an infected person. This can be done by applying the Infectious Diseases Act to kala-azar as a preventive measure for Assam.

I propose that certain villages should from time to time be notified under this Act, as villages from which unsupervised immigration should not be permitted.

Any one who asks permission to migrate from such villages, *i.e.*, to change his domicile by removing his family and household goods to an uninfected area, should not be permitted to do so unless with a clean bill of health for the family. This would be granted by the Sanitary Department on the report of the Sub-Assistant Surgeon in charge of the kala-azar travelling dispensary in that area. The District Executive Officers would make themselves responsible for the enforcement of this through the gaonburas and mauzadars. Lists of these notified villages should be circulated to all district officials and uninfected villages should be informed of the right to refuse admission to intending immigrants not possessing a clean bill of health.

I have discussed this proposal in all its bearings with Assamese gentlemen and officials, and they all agreed that no undue hardship would be involved in it, and that no opposition would be raised by the people, who understand the meaning of it and already themselves practise these measures. It is understood that no person has the right to exercise personal liberty of action to the detriment of others in the community, even though the loss of such liberty may involve some hardship to the individual. It is, however, recognised that careful supervision by superior officers would be necessary to prevent this measure being used as a means of oppression by venal minor officials. With the staff I have proposed it should be possible to do this, and it would not likely be necessary to notify any large number of villages unless the seriousness of the present situation were to become intensified by a further increase in the activity of the disease. Such notified villages should receive particular attention from the travelling dispensary and should be offered substantial assistance in carrying out measures of segregation and removal, to compensate them for the slight hardship involved in prohibition of migration.

It is important to note that this suggestion was put forward by Major L. Rogers as one of the recommendations based upon his exhaustive investigation, and embodied in his report in 1897.

His idea in advocating it was with the object of legalising the expulsion from non-infected villages of infected immigrants. I consider that a further step, and one likely to lead to the least hardship, will be to prevent the emigration of such infected persons at all.

The power of expulsion should be specifically included in the powers conferred by the Act, for I believe that the application of this Act in this manner is proving of considerable value in dealing with plague in the Punjab where it has enabled uninfected villages to refuse admission to suspected persons. A knowledge of the powers so conferred would be disseminated by the touring Sub-Assistant Surgeons, whose appointments I have proposed.

In view of the somewhat disquieting tendency to increased activity in the Nowgong district, I consider that there is distinct cause for action on these lines.

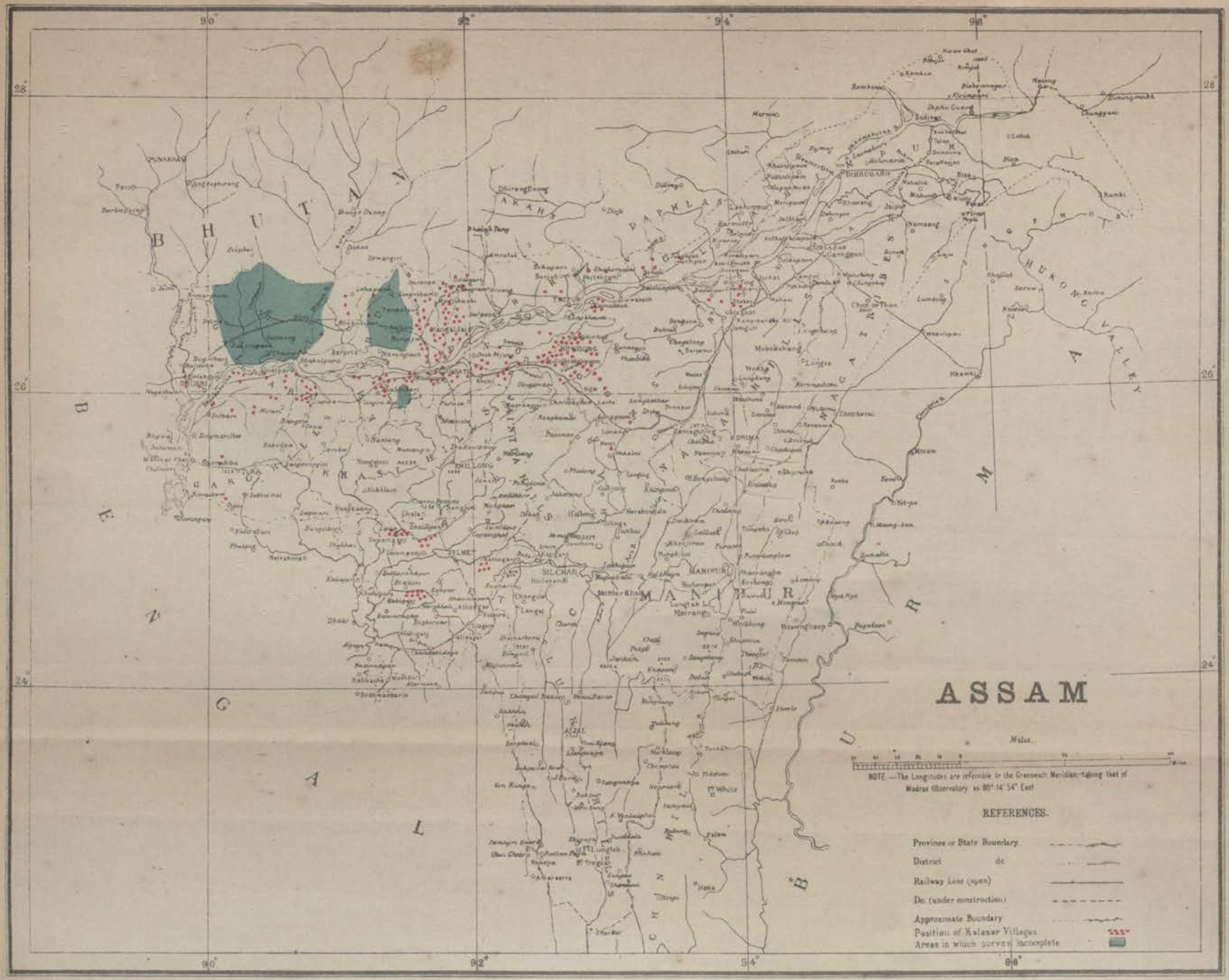
Need for continued research work.—While putting forward these suggestions for observation and control of the disease, I cannot emphasize too strongly the need for further research into the causation and treatment.

Without precise knowledge as to the causation of the disease and in the absence of a reliable remedy for its treatment, it is impossible to lay our axe at the root of the evil.

The absence of a remedy makes preventive measures extremely difficult, the people want a cure for the disease, and if we cannot offer this, our measures of segregation and prevention meet with little success.

The importance of medical science in the face of this scourge, and our inability to do more for its unfortunate young victims than to offer them quinine on the chance that possibly our diagnosis is wrong, and that the complaint is malarial, makes it a trying experience to see much of this disease for any lengthy period.

In the course of our work in Golaghat we know of several instances in which persons, proved by splenic puncture to have been infected with kala-azar, have recovered without any treatment. The disease is undoubtedly curable, if only we knew how to do so. It is to be hoped that this knowledge will soon become available.


ASSAM
Miles.
NOTE.—The Longitudes are referrible to the Greenwich Meridian, taking that of Madras Observatory as 80° 14' 54" East
REFERENCES.
Province or State Boundary
District do.
Railway Line (open)
Do. (under construction)
Approximate Boundary
Position of Kalazar Villages
Areas in which Survey incomplete
BHUTAN
BENGAL
BURMA
MANIPUR
SILCHAR
SHILLONG
DIBRUGARH
KOHIMA
HUKONG VALLEY
90°
92°
94°
96°
28°
26°
24°

APPENDIX II.

District Return.

Deaths from kala-azar by districts for 20 years in Assam.

Districts.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Cachar ..	2	1	..	..	..	..	..	..	..	..	..	..	3	..	22	5	6	2	3	2
Sylhet ..	30	2	9	4	..	3	..	3	147	168	721	1,020	955	743	576	561	454	866	549	394
Goalpara ..	623	384	265	298	232	134	161	110	62	49	44	64	86	90	49	32	81	87	135	192
Kamrup ..	2,490	2,149	2,059	2,244	2,756	1,693	1,745	1,262	830	1,014	651	458	499	438	516	386	378	450	354	358
Darrang ..	1,620	1,992	2,477	2,471	3,597	4,113	4,101	279	2,446	3,391	2,657	1,611	1,106	898	845	649	643	627	679	563
Nowgong ..	5,407	8,585	11,037	10,588	12,012	10,515	8,192	4,661	2,346	1,697	960	595	379	215	208	146	140	221	286	308
Sibsagar ..	1	2	..	..	..	..	..	..	..	..	..	..	..	6	11	2	1	..	34	31
Lakhimpur	50	36	..	..	..	..	..	..	..	..	..	..	2	17	..	5	..	50	11	..
Garo Hills	..	..	..	..	..	..	..	..	..	..	..	..	..	15	7	11	15	23	15	16
Khasi and Jaintia Hills.	24	13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total ..	10,247	13,164	15,847	15,605	18,597	16,458	14,199	9,015	5,831	6,319	5,033	3,748	3,030	2,422	2,234	1,797	1,718	2,326	2,066	1,891

Deaths from kala-azar in the District of Cachar.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
Silchar	..	..													..	..	..	..	..	..
Hailakandi ..	..	..													..	..	..	..	..	..
Rural.																				
Silchar	..	..													..	..	1	2	..	..
Lakhipur ..	2	..						Not available.							..	..	..	..	..	..
Katigora ..	..	..													..	3	..	..	..	..
Hailakandi ..	..	..													..	..	..	..	..	..
Tea Estates ..	..	1													..	2	5	..	3	2
Railways ..	..	..													..	..	..	..	..	..
Total ..	2	1													..	5	6	2	3	2

Deaths from kala-azar in the District of Sylhet.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Sylhet town ..	..	..	..											7	9	3	2	3	..	..
2. Moulvi Bazar town.	..	..	..											..	..	..	..	..	..	..
3. Karimganj „ .	..	..	..											..	..	8	1	..	..	1
4. Habiganj „ .	..	..	..											..	1	..	1	1	..	1
5. Sunamganj „ .	..	..	..											9	9	2	..	..	..	7
Rural.																				
6. Sylhet thana ..	1	..	..											94	91	77	53	127	122	39
7. Balaganj thana ..	29	2	..											137	101	96	95	119	68	45
8. Kanairghat „ ..	..	..	..											1	1	4	9	56	18	4
9. Moulvi Bazar „ ..	..	..	..											109	81	96	63	89	74	24
10. Kulawra „ ..	..	..	..					Not available.						5	4	..	..	30	..	..
11. Karimganj „ ..	..	..	..											35	24	51	3	..	15	..
12. Jaldhup „ ..	..	..	..											62	33	31	26	43	27	64
13. Sunamganj „ ..	..	..	..											62	54	22	10	20	5	39
14. Derai „ ..	..	..	..											42	39	52	9	..	16	11
15. Chhattak „ ..	..	..	..											175	97	83	146	268	108	51
16. Dharmapassa „ ..	..	..	..											..	..	..	9	14	18	5
17. Habiganj „ ..	..	..	..											..	23	17	18	21	3	8
18. Baniachong „ ..	..	..	..											1	..	5	5	16	5	1
19. Nabiganj „ ..	..	..	..											..	..	1	4	6	39	59
20. Madhabpur ..	..	..	..											..	..	4	..	40	16	31
Tea Estates ..	..	..	9											4	9	9	..	13	15	4
Railways ..	..	..	..											..	..	..	..	..	..	..
Total ..	30	2	9											743	576	561	454	866	549	394

APPENDIX II—*continued.*

Deaths from kala-azar in the District of Goalpara.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Dhubri town ..	6	2	3	..										..	..	..	..	..	..	..
2. Goalpara town ..	21	11	7	..										17	7	11	8	12	9	9
Rural.																				
3. Dhubri thana.	48	40	45	24										4	..	..	..	1	..	..
4. Agomoni ,, .	..	..	23	..										..	..	3	..	4	..	..
5. South Salmara ,, .	209	85	28	..										..	..	..	1	1	1	4
6. Bilasipara thana.	..	..	..	..										..	..	..	5	..	..	..
7. Goalpara ,, ..	332	245	155	204										20	9	10	23	7	9	20
8. Lakhipur ,, ..	..	..	1	..										4	3	1	3	5	6	6
9. North Salmara thana ..	..	..	..	..				Not available.						8	..	1	2	1	..	1
10. Dudnai thana ..	7	1	3	..										26	7	..	35	55	108	151
11. Bijni Duar ,, ..	..	..	..	..										4	2	..	..	..	..	..
12. 1st & 2nd Circle Sidli ..	..	..	..	..										4	..	..	..	1	..	..
13. 3rd Circle Sidli ..	..	..	..	..										2	21	6	..	..	1	..
14. 4th & 5th Circle Sidli ..	..	..	..	..										..	..	..	..	..	..	1
15. Guma ..	..	..	..	..										..	..	..	..	..	..	..
16. Ripu ..	..	..	..	..										..	..	..	..	..	..	..
17. Chirang ..	..	..	..	..										..	..	..	..	..	..	..
18. Forest villages ..	..	..	..	..										1	..	..	4	..	..	..
Tea Estates ..	..	..	..	..										..	..	..	..	..	1	..
Railways ..	..	..	..	..										..	..	..	..	..	..	..
TOTAL ..	623	384	265	228										90	49	32	81	87	135	192

Deaths from kala-azar in the District of Kamrup.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Gauhati town ..	261	146	107	..										53	43	31	10	20	12	13
2. Barpeta ,, ..	172	132	88	..										2	1	11	3	5	4	4
Rural.																				
3. Gauhati mauza .	433	255	197	470										96	97	72	132	119	53	110
4. Polasbari ,, ..	1,041	812	776	623				Not available.						141	107	54	70	116	100	75
5. Nalbari ,, ..	168	382	393	399										43	58	33	30	39	7	52
6. Rangia ,, ..	..	..	11	85										75	182	159	116	140	164	98
7. Barpeta including Raha & Barjuli	367	348	440	538										27	26	22	13	9	14	33
Tea Estates ..	48	68	47	..										1	2	4	4	2	..	..
Railways ..	..	..	..	..										..	..	..	..	..	..	..
TOTAL ..	2,490	2,149	2,059	2,115										438	516	386	378	450	354	385

Deaths from kala-azar in the District of Darrang.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Tezpur town ..	2	4	5	7										3	4	..	..	3	1	1
2. Mangaldai town .	15	11	13	12										4	4	..	1	2	..	2
Rural.																				
3. Tezpur mauza ..	..	1	13	60										81	81	66	64	30	37	53
4. Sootia ,, ..	1	3	..	55										10	21	8	12	3	2	12
5. Gohpur ,, ..	..	..	..	..										..	..	1	..	1	1	23
6. Behali ,, ..	..	..	..	..				Not available.						..	..	..	..	..	..	..
7. Mangaldai ..	1,587	1,924	2,405	2,144										50	53	31	48	40	69	45
8. Kalaigaon ..	12	5	28	107										265	156	117	141	93	88	72
9. Panay ..	..	..	..	..										342	373	384	329	420	457	321
10. Kariapara ..	..	..	4	4										100	120	37	40	18	19	21
Tea Estates ..	3	33	9	..										43	33	5	8	17	5	13
Railways ..	..	..	..	..										..	..	..	..	..	..	..
Chetgari ..	..	11	..	67										..	..	..	..	..	..	..
TOTAL ..	1,620	1,992	2,477	2,406										898	845	649	643	627	679	563

APPENDIX II—*concluded.*

Deaths from kala-azar in the District of Nowgong.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Nowgong town ..	184	205	160	91										17	9	13	11	12	17	21
Rural.																				
2. Nowgong mauza	2,958	4,534	5,530	5,206										65	49	38	31	44	82	94
3. Raha „ ..	1,315	2,355	3,133	3,243				Not available.						61	85	58	30	46	51	68
4. Shamaguri „ ..	930	326	1,937	1,802										43	37	34	56	97	99	92
5. Lumding „ ..	..	..	..	..										6	12	..	5	2	..	..
Tea Estates ..	20	165	277	246										23	16	3	7	20	37	27
Railways ..	..	..	..	..										..	..	..	..	..	..	6
TOTAL ..	5,407	8,585	11,037	10,588										215	208	146	140	221	286	308

Deaths from kala-azar in the District of Sibsagar.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Sibsagar town ..	..	..	..										..	..	..	..	..	..	..	..
2. Jorhat „ ..	..	1	1										..	..	..	..	..	..	..	..
3. Golaghat „ ..	1	1	..										..	..	..	..	..	..	..	..
Rural.																				
4. Sibsagar mauza	..	..	..			Not available.							..	..	..	1	..	..	..	..
5. Bontola „ ..	..	..	..										..	..	..	..	..	..	..	..
6. Sonari „ ..	..	..	..										..	..	..	..	..	..	..	..
7. Jorhat „ ..	..	..	..										..	..	..	1	..	..	..	..
8. Golaghat „ ..	..	..	..										..	1	10	..	1	..	32	29
Tea Estates ..	..	..	4										..	5	1	..	..	..	2	2
Railways ..	..	..	..										..	..	..	..	..	..	..	..
TOTAL ..	1	2	5										..	6	11	2	1	..	34	31

Deaths from kala-azar in the District of Lakhimpur.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Dibrugarh town..	1	..	..										..	1	..	..	..	..	..	..
2. North Lakhimpur town ..	1	..	..										..	..	..	..	..	..	..	..
Rural.																				
3. Dibrugarh mauza	..	..	..			Not available.							..	2	..	1	..	..	..	..
4. North Lakhimpur mauza ..	..	..	..										..	5	..	..	..	1	..	..
5. Dumduma mauza	..	2	..										..	..	..	..	..	..	..	..
Tea Estates ..	48	34	30										..	9	..	4	..	49	11	..
Railways ..	..	..	..										..	..	..	..	..	..	..	..
TOTAL ..	50	36	30										..	17	..	5	..	50	11	..

Deaths from kala-azar in the District of Garo Hills.

Circle.	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Urban.																				
1. Tura town ..														..	1	..	..	..	1	..
Rural.																				
2. Nibari mauza ..														7	..	5	14	18	9	11
3. Fulbari „ ..						Not available.								..	1	..	..	..	3	1
4. Rangapani „ ..														2	..	..	1	1	..	..
5. Mohendraganj mauza ..														6	5	6	..	4	2	4
Tea Estates ..														..	..	..	..	..	..	..
Railways ..														..	..	..	..	..	..	..
TOTAL ..														15	7	11	15	23	15	16

APPENDIX III.

List of places in which Leishmania found by splenic puncture.

District.	Serial No.	Names of villages.	No. of cases found.
Kamrup	..	Gorpara	..
		Mailhatta	..
		Ulubaria	..
Nowgong	..	Bhagzali	..
Darrang	..	Samatrapara	..
(Mangaldai) ..	..	Borarakhat	..
		Kotahi	..
		Upurkurna	..
Goalpara		Nishangram	..
		Halgiripara	..
		Garopara	..

List of villages found infected and the cases found in them.

District.	Serial No.	Names of villages.	No. of cases found.
Nowgong ..	1	Municipal ward I.	6
Western Circle	2	,, ,, IV	6
	3	Teliagaon	2
	5	Pahukatagaon	6
	..	Dudargaon Chechamukh ..	2
	32	Khutikatia	2
	31	Hemchoya	3
	28	Elengi Satra	4
	30	Kumargaon	1
	25	Birah Bebegia	1
	35	Toklai ,, ...	2
	54	Pachim Salmara	1
	55	Pub Salmara	2
	56	Kujarbari	1
	50	Nij Jagial	1
	51	Petboroh	2
	39	Baligaon	2
	80	Chamohora	1
	122	Boronha	3
	139	Dhing	1
	..	Majgaon	1
	316	Digaldari	2
	315	Daobali	3
	301	Barpujia	1
	387	Bagora	1
	374	Tetalia	1
	381	Bhakatgaon	1
	498	Bhogjopgaon	1
	496	Paschim Nowgong	2
	484	Nowholagaon	3
	540	Barpaik	1
	532	Dhoramtol No. II.	1
	574	Nizjorabari	1
Eastern Circle	3&1	Nowgong town ward No. II & III ..	10
	10	Chhota Haiber	5
	5	Maj Pathari	2
	6	Nam ,, ...	1
	3	Bhotaigaon	1
	13	Dimaruguri	2
	38	Mirongial	1
	44	Barpathari	1
	70	Puranigodam	1
	90	Sutorgaon	1
	88	Rupahi Bhakatgaon	1
	260	Jaklabandha	2
	308	Deorisilabandha	3
	311	Madhatari	1
	293	Lungichuk	3
	264	Chutialgaon	1
	313	Silghat	1
	290	Kuaritola	3
	..	Amguri	2
	43	Deodhorgaon	1
	332	Barkundali	3
	335	Nongomthagaon	5
	336	Nagasain Khat	2
	337	Kamargaon	4
	25	Katanigaon	1
	343	Dyangia	11
	349	Chengmora	5
	352	Tabukigrant	5
	359	Kacharigaon, No. I	4
	360	,, No. II	3

APPENDIX III—*continued.*

List of villages found infected—continued.

District.	Serial No.	Names of villages.	No. of cases found.
Eastern Circle—*contd.* ..	362	Sagunbahi	6
	364	Jamurmur	4
	367	Pachimkathiatoli	1
	369	Nambor Lalungaon	3
	371	Sarupather	3
	377	Bhelewguri	4
	392	Tetelisora	2
	394	Derrangi	1
	395	Niz Kampur	1
	397	Ghelani	5
	398	Deb Narikoli	2
	400	Chorai Hazi	2
	402	Borpothiagaon	2
	403	Bhotbhotia	7
	410	Baliramgaon	6
	414	Kutkatia Kakatgaon	4
	412	Nagaonpam	2
	466	Jugijan	4
	465	Bhedew	4
	469	Niz Doboka	1
	460	Nam „	2
	427	Lanka	1
	425	Namkharikhana	1
	426	Alichya	1
	514	Halikhalijan	2
	511, 152	Lumding	5
Darrang	29	Ward No. III	1
	4	Parbatia	2
Tezpur Sub-division ..	19	Kalibari	1
	25	Kataki Chuburi	1
	24	Dawgaonpukri	3
	28	Sapat Chuburi	5
	147	Borati	1
	215	Bamingabari	1
	228	Atitola	4
	301	Nokhonia Pathar	1
	334	Bagijuly	2
	335	Batiamari	2
	387	Garuabari	3
	422	Gahigoriagaon	3
	495	Marmkuri	1
	524	Gatonga Karhadal	1
	544	Khanoparbataburi	1
	528	Madhubi Saikia Chuburi ..	4
	534	Bindukuri	2
Darrang	1	Mangaldai Town	1
	3	Tengabari	2
Mangaldai Sub-division	12	Dewnagaon	1
	5	Gadhiapara	1
	20	Niz Magalbasa	3
	37	„ Kalaigaon	1
	76	Goriapara	1
	118	Niz Rangamati	2
	123	Hazerika Chuburi	2
	124	Pithakhoa	1
	128	Setmadar	1
	126	Debananda Satra	1
	135	Satghoria	1
	139	Maraigaon	1
	153	Kholaigaon	1
	156	Upar Kurua	10
	190	Bejalibari	1
	191	Metapara	1
	206	Borkolajhar	1
	205	Patharughat	1
	211	Battabari	2
	212	Chengapara	1
	214	Chengapara	1
	222	Khatara	2
	246	Kamargaon	1
	235	Borigaon	1
	254	Katehi	1
	255	Nagaon	1
	256	Chamotiapara	4
	259	Kharkhoapara	1
	278	Bororakhat..	6
	285	Chenialpara ..	1
	287	Bagoribari	1
	288	Sukliapara	1
	289	Jalukbari	1
	293	Kohorukuchi	3
	296	Rampur	1
	306	Kaljuri	1
	307	Balisitha	4
	310	Chabemoholiapara	2

APPENDIX III—*continued.*

List of villages found infected—continued.

District.	Serial No.	Names of villages.	No. of cases found.
Mangaldai Sub-division—*contd.*	308	Rangajulikhat	1
	335	Rupukhat	2
	337	Charanpara	3
	338	Mohoteapara	1
	365	Dongpara	1
	382	Kakalbhangi	6
	384	Nagarasara	3
	413	Kasia	1
	414	Niz Harisinga	1
	417	„ Japarabari	2
	423	Ghagrapara	6
	434	Gorakakh	5
	454	Pub Nalbari	1
	468	Kacharitol	1
	469	Maklikanda	7
	473	Hapabari	6
	477	Tamuragaon	2
	478	Niz Dola	1
	489	Pakhimuri	1
	525	Jurabari	4
	529	Sangalbari	5
	542	Jhakaabri	2
	531	Baliarara	1
	544	Borigaon	6
	700	Majgaon	1
	707	Bhakatpara	2
		Thana Goalpara.	
Goalpara	168	Dalgoma	1
Goalpara Sub-division ..	169	Kadamtala	1
	146	Marnai	5
	140	Dubapara	2
	179	Sharaara	2
	176	Matia	3
		Thana Dudnai.	
	142	Lakmakundi	1
	140-43	Nishangram	8
	79	Shiali	1
	52	Sardapara	3
	61	Khamar Manikpur	1
	145	Thekashu	10
	40-136	Halgiripara	8
	38	Rowmari	6
	39	Digli	7
	146-55	Balasara	5
	94	Bargaon	1
	36	Shialmari	5
	28	Bangalpara	1
	35	Mandalgram	4
	15	Upartalla	12
	174	Duramari	3
	172	Delguri	2
	23	Lalpara	3
	31	Panna-pur	1
	..	Mowamari	1
	96	Salpara	8
	160	Manopara	2
	30	Puranivita	1
	..	Majengpara	2
	147	Bhodeyapara	3
		Thana Lakhipur	
	268	Dasaraka	2
Dhubri Sub-division ..	1	Ward No. I	1
	30	Baruadanga (Pratabganj) ..	1
	69	Biskhoa	1
	77	Kidor	1
	68	Kanduri	2
	82	Nalia	1
	117	Mahamayarchar	1
	123	Sebaturi	1
	289	Pataodhon	2
	290	Verakhoa	1
	296	Kalsabhanga	1
	533	Thetaripara	1
Kamrup]	..	Ward No. I. Uzan-bazar ..	14
	..	Ulusarani	1
	..	Ulubari	6
Gauhati Sub-division ..	5 & 6	Sarania	3
	6	Silpukri	3
	7	Pinihinpara	2
	9	Bamun Maidan	3
	16	Nunmati	1
	..	Barmutaria	1
	..	Bongaon	4

APPENDIX III—*concluded.*

List of villages found infected—concluded.

District.	Serial No.	Names of villages.	No. of cases found.
Gauhati Sub-division—*contd.*	..	Kherguli	2
	8	Maidam	5
	21	Kalitakoch	2
	31	Fatasil	3
	32	Matghoria	4
	38	Saokuchi	3
	43	Dakhingaon	1
	44	Udulbakara	1
	45	Haluna	5
	47	Bhaghora	6
	51	Dharbam	1
	54	Khalaibari	5
	55	Bangpur	2
	66	Tapatuli	6
	67	Kahikuchi	2
	69	Hapura	1
	71	Raon	1
	72	Haragaon	1
	74	Tataliguri	1
	98	Kachia	9
	116	Jutikuchi	2
	117	Grinod Bagish	1
	121	Sadilapur	3
	144	Hudumpur	8
	122	Kaotpara	1
	134	Malihata	5
	135	Lachana	1
	..	Malchata	1
	150	Kallapara	2
	144	Parakuchi	3
	..	Sarapara	3
	..	Uparhali	2
	138	Sarapara	4
	146	Rangamati	1
	..	Uparhali	1
	151	Dhikuapara	4
	152	Jharapara	1
	153	Bippari	1
	162	Mugakhal	1
	164	Bhaguabari	1
	170	Manman	1
	184	Dhupguri	1
	239	Langkhona	1
	..	Manman	1
	213	Kochpara	1
	212	Galihaka	4
	248	Nizbagai	1
	258	Satubari	1
	..	Bharkibhita	1
	294	Nagarbera	8
	299	Malacha	1
	293	Dukuchi	2
Kamrup	10	Jalikata	1
Barpeta Sub-division ..	59	Pipla	1
	76	Kulbari	1
	92	Tukrakochi	1
	284	Simla	2
	157	Bartarigaon	1
	228	Bhalaguri or Loasur	1
	242	Kolitapara	2
		North Kamrup.	
	..	Piahkhota	1
	..	Dinkar	1
	..	Dekar Kuchi	1
	..	Sundarisal	2
	..	Ghopla	1
	..	Singra	1
	..	Majgaon	1
	..	Avoypur	1
	..	Rangmahal	2
	..	Bar Sandra	2
	..	Sila Mahikhata	1
	..	Rajadori	2
	..	Sila	1
	..	Balaibil	3
	..	Bargaon	1
	..	Deoduar	2

THE BACTERIOLOGY OF THE COLOMBO TOWN AND WELL WATER.

BY

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THE object of the present paper is to give an account of an attempt to develop methods for the bacteriological examination of water suited to the conditions prevailing in Colombo and the Western Province of Ceylon.

It is now becoming recognised, thanks largely to the pioneer work of Clemesha in India, that no method devised for the detection and estimation of the nature and extent of fæcal pollution in water supplies is universally applicable to all conditions.

We now possess definite evidence that the bacterial flora of the intestinal canal of man and the lower animals, the natural microbic content of inland surface and well waters, the relative activity of the various processes concerned in the natural purification of water supplies, may vary to a remarkable extent in different localities.

I adopted initially much the same methods as I had been accustomed to employ in England. These methods were very similar to those developed by Dr. Houston in the Laboratories of the Metropolitan Water Board. It was soon evident that it would be necessary to substitute liquid media for sugar gelatine for the fermentation tests. After six months' trial the enumeration of colonies on gelatine plates was abandoned. It is quite practicable to work with Hearson's cool incubators at tropical temperatures. The large sized incubators require, however, a very large amount of ice and constant attention to obtain satisfactory results. The small sized incubator still in constant use for testing the liquefying power of organisms on gelatine takes over 30 lbs. of ice per diem to maintain a temperature 20° C. There is no such difference between the colony counts on agar and gelatine as obtains in temperature climates. The average temperature prevailing in Colombo is 81° C. which appears to be the optimum temperature for the growth of the ordinary water organisms. There is *often* no difference, however, between the number of organisms grown at 37° C. and at room temperature on agar plates in 72 hours.

I commenced the systematic examination of the Colombo water-supply in April 1912. The city is supplied with water from an upland surface catchment area at Labugama. The rainfall, amounting on an average to 161 inches per annum falling on a catchment area of 2,305 acres is collected in a reservoir of 149 acres formed by the construction of a dam across the narrow northern end of a valley in the hills. The valley was formerly traversed by a tributary of the Kelan river. The spill level of the water in the reservoir is 360 feet above mean sea-level. The maximum depth is 59 feet. The steep hills encompassing the reservoir are covered with dense jungle inhabited by monkeys, leopards, deer, and doubtless numerous other animals of the lower orders. The banks surrounding the reservoir are cleared of vegetation or a depth of 2 chains annually. The whole area is strictly preserved from human habitation and from domestic animals.

The reservoir is constantly fed with water by two large streams passing down from the hills, and about sixteen small streams, some of which cease to flow in dry weather.

At present the water is simply screened before being passed into the two 20″ mains which carry the water 25½ miles to Colombo.

A Jewell gravity filter installation is now being erected at Labugama. Chemically the water is remarkable for its low total solids and its softness. The following is a typical analysis by the City Analyst:—

Total solids ...	1·0
Chlorine ...	·6
Free ammonia ...	*Nil.*
Albumenoid ammonia ...	·006
Nitrates and nitrites ...	*Nil.*

The figure for albumenoid ammonia occasionally ranges rather high, but otherwise the water is free from objection chemically except on the score of an excess

of suspended matter. Geologically the catchment area is formed of cabook overlaying gneiss.

The water is distributed in Colombo from two service reservoirs, each of a capacity of 8 million gallons. There are about 200 miles of distributing mains within the city limits. Except in the poorer quarters the service is mostly independent of street standpipes. It is interesting to note that the average count on agar of water which has passed through the service reservoirs differs so materially that it nearly always is possible to judge from which district any particular sample is derived; provided it is not taken too near the border line between the two areas.

The first series of 100 samples from street standpipes and all the reservoir samples without exception were collected under my personal supervision with all the usual precautions. For taking samples at a depth I use a modification of Thresh's apparatus.

In each series of analyses of the water in the Labugama reservoir at least three samples were taken, one from the surface, one from the bottom, and one approximately half-way. All the results given in Tables I, II and III were obtained from samples taken from a boat in the middle of the reservoir about 200 yards from the outlet end. The water supplied to the town is usually drawn off from the 12-foot level. Prolonged periods without rainfall are very rare at Labugama. As a rule, the driest season of the year is between the end of January and the beginning of April. In the year 1913, however, the rainfall was exceptionally heavy during the first six months. During July, August and September the rainfall was very much below the average.

The bottles containing 250 c.c. are placed in sterile tins and packed in ice in a special case. The ice boxes containing samples from the Labugama reservoir are conveyed by motor car to the laboratory without delay. I am personally responsible for all the bacteriological examinations, the results of which are utilised in this paper.

In the examination of the first few samples of town water glucose bile salt broth was employed in the presumptive coli test. The study of the micro-organisms isolated from the various decimal dilutions giving acid and gas in this medium showed that the result afforded no definite indication of the number of the more characteristic fæcal organisms present in the water, unless it had been recently polluted.

I now mainly rely on lactose litmus bile salt broth for the determination of the acid and gas line. For accurate results I use the dilutions given in Table II. After careful perusal of Clemesha's work on the " Bacteriology of the Surface Waters in the Tropics " I decided in October 1912 to apply similar methods to the study of the Colombo water-supply. In addition to isolating 10 colonies from the 50 c.c. tube, lactose fermenters were isolated from other lactose tubes showing acid and gas after 24 hours and tested for indol. At a time when the main supply contains no " Lagin " organisms the use of Houston's method, using glucose bile salt broth, enabled me to detect pollution of a standpipe sample as a result of an accidental injury to a street main. The great disadvantage of the method is the existence of certain " Lagin " organisms resistant to sunlight and storage which occasionally predominate after prolonged storage has purified the water. This difficulty will be doubtless greatly diminished when the Jewell filter plant is in operation.

I prefer azolitmin as an indicator for use in the liquid media to either ordinary litmus or neutral red. Occasionally one comes across samples of this substance that are unsatisfactory, but as a rule, it gives good results in ·1% solution.

All media except those containing sugars are standardized to + 10 acid on Eyre's Scale using phenolphthalein as an indicator. The sugar media used in testing lactose fermenters are slightly alkaline to litmus, *i.e.*, slightly acid to phenolphthalein.

The ordinary neutral red lactose bile salt agar is rendered slightly acid to neutral red. The glucose bile salt agar is + 10 acid to phenolphthalein. I have not, in practice, experienced any difficulty from the inversion of lactose when care is taken not to prolong the sterilisation unduly.

In general the formulæ used in the preparation of culture media are very similar to those given in Dr. Houston's report to the Metropolitan Water Board. The sugar media are put up in 1% solution in peptone water tinted with azolitmin in 4″ × ½″ tubes. Special small racks are used for the sake of economy in incubator space. In the case of adonite and dulcite the use of capillary fermenting tubes and a ·5% solution of the carbo-hydrate effects a great economy.

I now use the technique recommended by Clemesha for the isolation of lactose fermenters from the ordinary liquid media, plating out after 18—24 hours. The tube usually selected is one containing 25 or 50 c.c. of the water. My usual practice is to pick off only red colonies from well-dried plates of the neutral red bile salt lactose agar with a platinum or iron wire into peptone water, and after from 6—24 hours' incubation to inoculate glucose broth, saccharose, dulcite, and adonite

azolitmin peptone water with the aid of a small pipette. I find this method gives more uniform results than any other I have tried.

The peptone water is tested for indol formation after three days' growth with Böhmes' reagent. I propose to give Rivas' medium an extended trial and may decide to adopt it in place of the ordinary peptone water for the formation of indol. The results are read off in one hour. Vosges Proskauer's reaction is tested for by the addition of sufficient saturated solution of caustic potash to slightly warm the contents of the tube. Bright red coloration usually appears in one to three hours. The results are read off on the following day.

Both these tests performed in this manner appear to be reasonably reliable, particularly the indol reaction. In obtaining the results set forth in Tables II and IV annexed to this paper, motility was tested for by the examination of an 18-hour culture of glucose broth. I consider, however, that the character is too variable to be of real service in routine tests for the classification of organisms of the coli group. Careful study of several young cultures of an apparently non-motile organism frequently results in the discovery of an undoubted motility. Table V test 10, group II organism appeared at first sight to be non-motile and was put down as B. S. chafferi. Subsequent tests showed it was motile. I possess a culture of B. typhosus obtained from the Lister Institute, which is now absolutely non-motile. The bacillus was decidedly motile when I first examined it. It still possesses every other character of this organism. I have kept cultures of each of M'Conkey's four groups under observation for over a year. So far the only variations that have appeared are in the motility, and in the extent to which saccharose is fermented.

I have decided to abandon the use of inulin peptone water for routine work this year. I have never succeeded in isolating an inulin fermenter from human fæces in Colombo; and on only four occasions from the Colombo water-supply. Two of these organisms were from the dry weather samples, two were found during the rains. Clemesha attaches importance to the presence of some inulin fermenters, as for example B. oxytocus perniciosus, as an indicator of recent pollution. I shall therefore continue to test for the presence of these organisms by inoculation of quantities 10 c.c. and upwards into inulin broth at the height of the monsoon rains.

Presence or absence of acid and gas in the sugar tubes is recorded after three days' incubation at 37°C. There is a slight advantage in incubating 4 to 7 days in the point of view of accuracy, but experience shows that the gain is by no means commensurate with the inconvenience and loss of time entailed.

I do not as a rule pass the red colonies isolated from the lactose plates through a lactose peptone water. This procedure was adopted for testing about 500 colonies. In every case without exception acid and gas developed. In most cases the colonies isolated from the smaller quantities of water for the detection of "Lagin" organisms, are simply tested for indol after three days. On many occasions, however, I have separated the species by M'Conkey's test. If isolated before 24 hours' growth in the primary broth, the organisms correspond fairly closely to those isolated from the largest quantity of water. That is to say, the organism found in the lowest tube showing signs of acid and gas within 24 hours is usually the predominant organism in the large tube.

Before discussing the significance of the results given in Tables I, II and III, I should like to draw attention to Table IV which sets forth the results of the application of M'Conkey's test to 250 lactose fermenters isolated from 25 fresh normal human fæces—22 Natives and 3 Europeans. The Natives were nearly all milk-vendors. The white colonies on the lactose bile salt neutral red agar were tested for the bacilli of typhoid, paratyphoid, and dysentery, with entirely negative results in these particular cases. A few determinations were made of the lactose fermenters occurring in Colombo sewage from samples taken from a pumping station which mainly deals with latrine sewage. The relative proportion of group 2 organisms proved to be much smaller than in fresh fæces; B. lactis aerogenes was much more common.

The following table shows the percentage grouping of 241 lactose fermenting organisms isolated from human fæces by M'Conkey in England: 1,207 by Clemesha in various parts of India: and 250 from fresh human fæces in Colombo, and 174 from the Colombo water-supply during the rains:—

	M'Conkey Human Fæces.	Clemesha Human Fæces.	Colombo Human Fæces.	Colombo water-supply during rains.
Group 1 ...	34	53·2	20	12·6
Group 2 ...	38	17·4	45·2	42·9
Group 3 ...	15	6·8	25·2	34·5
Group 4 ...	12	22·2	9·6	9·8

Several human fæces yielded nothing but B. coli communis.

The organisms were cultivated and tested in precisely the same manner as the lactose fermenters described in Tables II and V. A small proportion of the organisms described as B. coli communis formed a trace of acid in saccharose after the third day. In these instances a few bubbles of gas were often visible when the cultures were kept under observation for longer periods.

I have experienced much difficulty in working with saccharose on account of the appearance of traces of glucose after the substance has been exposed to the air for some time. Saccharose appears to be slowly hydrolysed in the moist, slightly acid atmosphere of Colombo.

I make it a routine practice to test carbohydrate media against known organisms which have shown no tendency to vary in their fermentative properties. Many of the bacilli characterised have been cultivated on a variety of media in addition to those noted, including raffinose, salicine, mannite, milk, gelatine, and neutral red glucose broth. By the use of raffinose, salicine, and inosite in particular, it would be possible to further subdivide these organisms. Formation of acid and clot in milk was closely parallel to the vigour with which lactose was fermented. The behaviour of these microbes in neutral red broth proved to be variable. It is difficult to get different batches of the medium to give precisely the same results. The liquefaction of gelatine is undoubtedly a character of great value for differentiating species. It is unfortunate that it should be necessary to incubate the cultures for a month to obtain reliable results.

The ordinary tests used in water analysis for a separation of lactose fermenters into species, Vosges Proskauer's reaction, indol test, fermentation of saccharose, dulcite, adonite, and inulin are in themselves very useful and on the whole reliable. It is questionable, however, whether they are altogether adequate. I propose to give an extended trial to salicine in place of inulin; inosite is too expensive for routine use, while raffinose is too unstable.

In two noteworthy instances the tests proved inadequate in practice. At certain seasons, specially in periods of comparatively dry weather following heavy rain, an interesting organism appears in Colombo water in large numbers. It is probably never entirely absent. For the sake of convenience I will call it Bacillus C.

The principal characters are as follows :—

It is a motile, coliform bacillus, very slightly gram positive. Gelatine is not liquefied in one month. Milk becomes acid in three days without clotting. Vosges Proskauer's reaction is very positive. No indol is produced after seven days' growth in peptone water. Broth becomes uniformly turbid with a slight scum and deposit after three days. On neutral red bile-salt lactose agar it forms large white colonies with occasional red centre. Deep colonies are red or brownish red. If the medium be slightly alkaline the organism fails to develop in 24 hours.

Acid is formed from lactose in 1 to 2 days. Gas usually appears, in small quantity, on the third day. Glucose and saccharose are fermented with great vigour: mannite, sorbite, maltose, dextrine and arabinose with less vigour: raffinose and salicine are slightly acted upon; adonite, dulcite, inulin and isodulcite are not fermented. This organism differs from Clemesha's description of his Bacillus P. in having a distinct action on lactose and in fermenting mannite. In addition it is not very resistant to sunlight and is found in largest numbers at the bottom of the Labugama reservoir.

The Bacillus cloacæ according to Clemesha is the lactose fermenter principally found at bottom of lakes in the Tropics. It is impossible to distinguish between the Bacillus cloacæ and the Bacillus C. by the ordinary tests: Bacillus cloacæ liquefies gelatine slowly while Bacillus C. has no action upon it. M'Conkey summarises a number of descriptions of the properties of B. cloacæ by different observers in a paper on lactose fermenting bacilli in fæces.[1] In these descriptions B. cloacæ would appear to be a feeble lactose fermenter constantly motile and constantly liquefying gelatine. Bacillus C. appears to occupy a similar position to Clemesha's bacillus in the natural purification of Ceylon water. It was the only organism surviving at the bottom of the Labugama reservoir in September.

On reference to Table V, test 9, it will be seen that an organism, appearing after long exposure to sunlight, might be either B. cloacæ or Bacillus C. It fermented lactose decidedly and liquefied gelatine and is therefore probably B. cloacæ.

On tests 10 and 11 of the same series an organism having the usual characters of B. coli communis appears after several days sunning. This organism differed from the type only in a lesser degree of motility, in a tendency to ferment saccharose, and in the constant formation of a marked scum on the surface of broth and peptone water. The two organisms were grown for comparison in twenty different carbohydrate media.

In the experiments on the effect of sunlight on fæcal micro-organisms conducted by Captain Archibald[2] at Khartoum (1910) an organism described as B. schafferi survived for long periods.. The only important difference between this organism and B. coli communis seems to be that the former is non-motile, and produces less acid and gas than the latter.

There is no doubt that there is a great and speedy diminution in the number of B. coli communis which appear in water immediately after it has undergone fæcal pollution. There is also no doubt that in the case of the Labugama reservoir the diminution in the number of B. coli communis during self-purification is relatively greater in the lower levels of the water than that of other fæcal organisms.

It is open to question whether the class 2 organism found on the surface in February, April, May, and November series, is a resistant variety of B. coli communis or another species with the same fermentative powers. I am inclined to take the former view.

For the sake of convenience I have attached a name or number to the various organisms in Table III. It is highly probable that a careful comparison between these organisms and to those to which this name or number was originally attached would in some cases show that there are important differences between them.

I have been unable to discern any definite seasonal variation in the species of lactose fermenters inhabiting the human intestine, such as Clemesha found to prevail in Madras and other parts of India. I did not, however, devote much attention to this question before February, 1913.

Samples of fæces examined during the hot weather in April and in August, 1913, during a drought, showed the same predominance of B. coli communis as the rest.

The Bacillus coli communis is found in recently polluted well waters and in the town supply after rain, throughout the year. It is doubtless possible, however, that extended investigation may show that recognizable changes do occur in the fæcal flora of the inhabitants of Colombo, but to a much less extent than in certain parts of India.

The value of the separate species method depends chiefly:—

(1) On the possibility of devising a convenient method of isolating the various species in something like their original proportion in the water. I consider that the technique devised by Clemesha and his colleagues is sufficient for the purpose. Feeble lactose fermenters are apt to be suppressed.

(2) On the adequacy of the tests employed for the differentiation of a separate species. I consider M'Conkey's tests are nearly the best available at present for routine work. No entirely satisfactory method has yet been devised.

(3) On the existence of a relationship between particular species and particular stages in the pollution and self-purification of a water.

A comparison of the results of the May and September series of Labugama analyses exhibits a remarkable change not only in the total number of fæcal organisms but in their species. A spell of dry weather following rain at Labugama is always indicated by decrease in the number of B. coli communis and the appearance of increasing numbers of organisms such as B. lactis aerogenes and No. 67; giving the Vosges and Proskauer's reaction and energetically fermenting saccharose. Nevertheless, I find it difficult to classify the fæcal organisms found in these waters in a definite scale of susceptibility to the influence of storage and sunlight.

I have conducted a number of experiments on naturally and artificially polluted waters exposed to the action of sunlight in tanks and glass troughs. Particulars of one such experiments are given in Table V. In view of the somewhat inconclusive results hitherto obtained, I propose to continue these experiments. The chain of events taking place in the small scale experiments does not appear to be so regular as the corresponding changes in lake and river waters under varying conditions of sunlight and storage, of aeration and oxidation, and competition between micro-organisms and the infusoria.

The separate species method, in spite of its defects, is of great value for the study of water supplies in Ceylon. It is capable of furnishing information as to the degree of self-purification which a water has undergone, unobtainable by any other method.

The results of the separate determination of the acid and gas line in glucose and lactose media are set forth in Table III. The first series of analyses of Labugama water in which this method was employed was carried out on 6th November 1912. The results are almost identical with those obtained by the same method under similar conditions on 6th November 1913. The results for September 1913 are not tabulated on account of the few organisms present. The Bacillus C. was present alone in 50 c.c. of the deep sample. One of the 1 c.c. lactose tubes showed a little acid and gas after three days' incubation. Two of the glucose tubes containing 1 c.c. showed marked acid and gas in 48 hours.

On many occasions I have tried the experiment of inoculating a lactose tube from a terminal glucose tube, when the difference between the results in the glucose

and lactose broth has been marked. Nearly always acid and gas develop in the lactose medium in three days. In every case but one the organism isolated from these tubes turned out to be the Bacillus C.

The difference shown in the tables between the 72 hours results in lactose and glucose is therefore to be explained by the inability of a feeble lactose fermenter, attenuated by storage, to ferment lactose without preliminary rejuvenation in glucose. The effect of attenuation is discernible in the glucose medium but it is much more marked in the case of the less easily fermentable lactose.

Jackson and Muer[8] recommend a glucose liver broth as the most suitable medium for developing acid and gas from attenuated fæcal organisms. The more vigorous lactose fermenters are not so easily attenuated as the less vigorous less, typically intestinal, microbes such as the Bacillus C.

It has to be borne in mind that the Bacillus C. does not form bright red colonies on the surface of neutral red lactose agar plates, and is liable to be outgrown by vigorous lactose fermenters in fluid media. It may not be isolated at all from the 50 c.c. lactose tube and yet be found exclusively in the 100th c.c. glucose. I failed to detect the Bacillus C. in the course of sunlight experiments with sewage. Three determinations of the acid and gas line in glucose and lactose were carried out in the course of sunlight experiment 4. The acid and gas line in glucose and lactose was very close together throughout the experiment, any difference being due to the attenuation of a lactose fermenter. The degree of divergence between the acid and gas lines in glucose and lactose broth is a valuable index of the amount of self-purification which has taken place in a polluted water containing organisms such as Bacillus C. or Clemesha's Bacillus P.

I find that evidence of equal, if not greater, value can be obtained in a simpler manner by a comparison between the acid and gas line in lactose after 24 hours and the number of colonies per c.c. growing on a neutral red glucose bile salt agar plate. The reaction of the medium is important. A comparatively slight alkalinity barely sufficient to change the colour of the neutral red, has a marked effect upon the number of organisms growing in 24 hours. The Bacillus C. is particularly sensitive to alkali. Even vigorous lactose fermenters such as B. lactis aerogenes and B. coli communis rapidly diminish in number as the alkalinity increases, though their relative proportion is not much effected. The feeble lactose fermenters are speedily extinguished. In experiments with fresh and sunned emulsions of sewage the number of colonies growing on this medium corresponded closely to the number estimated by the dilution method in glucose bile salt broth. A fairly accurate estimate of the number of fæcal organisms in water and sewage can be made by means of the dilution method in glucose bile salt broth, if the water or sewage has not undergone much self-purification. When the self-purification process is advanced and many of the fæcal organisms attenuated the acid and gas line in media of uniform composition containing lactose or glucose is not reliable as a means of estimating the actual number of fæcal organisms still living in the water. In my experience, however, duplicate determination of the acid and gas line in the same medium do not show material differences.

When interpreting the results of the bacteriological examination of an upland surface water in Ceylon I attach importance to the following:—

(1) The number of vigorous lactose fermenting organisms in the water; the larger the number found, as estimated from the acid and gas line in lactose bile salt broth after 24 hours' incubation, the greater the probability of serious and recent fæcal pollution. If these organisms on isolation are found to be capable of producing indol in peptone water in three days, the evidence in favour of recent pollution is considered to be materially strengthened.

(2) Characters of the lactose fermenters isolated from 20 to 100 c.c. of the water after 18 to 24 hours' incubation at 37° C. The predominance of B. coli communis is regarded as especially suspicious of recent pollution; of B. lactis aerogenes and various organisms of class III as evidence of self-purification; of Bacillus C. as indicating that the water has undergone the safety change.

(3) The degree of coincidence between the acid and gas line in the following media, glucose and lactose bile salt broth after 48 hours' incubation, lactose bile salt broth after 24, 48, and 72 hours' incubation, and between the acid and gas line in lactose bile salt broth, and the number of red colonies growing on glucose neutral red bile salt agar in 24 hours at 37° C. Close correspondence between these figures is regarded as an item of evidence in favour of recent pollution.

(4) The correlation between the number of "Lagin" organisms and the number of lactose fermenters of all kinds. If there is reason to believe that a large number of the "Lagin" organisms initially present were

of resistant type, then this item of evidence becomes much less weighty.

(5) The presence or absence of streptococci. I have twice found streptococci in the Colombo water-supply ; once in the sample from a standpipe fed by an accidentally damaged street main in May 1912 : again in a sample taken after heavy rains from a flooded stream at the Labugama reservoir in May 1913. This water contained over 100 B. coli communis and B. neapolitanus per c.c. and gave 1,537 colonies per c.c. on agar. As a positive character the detection of streptococci in a water is strong evidence in favour of pollution. The technique commonly employed for the isolation of streptoccoci does not appear to be so reliable as the corresponding test for B. coli.

During 1912 I have applied the enteriditis sporogenes milk test to the waters examined at the municipal laboratory using quantities of 20 c.c., 10 c.c. 1 c.c., ·1 c.c., ·01 c.c. A typical enteriditis change usually appeared with 20 c.c. of the town water, and sometimes in 10 and 1 c.c. On microscopic examination of the whey and anærobic sub-cultures I found two different types of anærobic organisms. Both were gram negative and actively motile with large oval spores. One grows in filamentous form, the other as a stout rod. I have never seen a typical B. enteriditis sporogenes of Klein in Ceylon. I have sought for it in polluted water, fæces and sewage without avail. On several occasions I have inoculated the whey of these milk cultures into guinea-pigs without producing the slightest effect. My experience in England has been entirely different. Usually it is very easy to isolate a typical B. enteriditis sporogenes from fæcally polluted liquids. For the present I have abandoned the test for routine work till further research has elucidated the significance of the anærobes found in the milk cultures. The colony count on agar is greatly influenced in pipe water samples by the condition of the organic coating which lines the interior of the pipes.

Fifty-four well water samples have been bacteriologically examined since July 1912. There are a large number of wells in Colombo principally used for bathing and washing purposes. The water after use is drained away from the filtration area, which is often paved with concrete. The tube of the well is usually of brickwork partially rendered in cement. Most of the wells possess an adequate coping. All of them are open. Washing places are separate from the wells and are served with water drawn up in buckets. The soil in which the wells are dug is mainly cabook towards the north of the city ; elsewhere the soil is usually ferruginous sand and clay. Very few of the wells contain more than a few feet of water. Many of them dry up in times of drought. The ground water-level varies from 2 feet to 50 feet from the surface.

The whole of the sub-soil water in the Colombo district shows evidence of fæcal pollution ; the degree of this pollution being roughly proportionate to the nearness of the sub-soil water to the surface and to the density of the population in the neighbourhood. A few wells of sound construction situated in isolated spots yielded good water containing only a few fæcal organisms of a resistant type.

The interpretation of the results of the separate species method as applied to well waters in Colombo is greatly complicated by the circumstance that the soil in which the wells are dug possesses a bacterial flora of its own. I have recently begun to study the changes produced in water passed through an artificial filter built up of cylinders of cabook rock cemented on the outside. Water rapidly passes through the cabook under a few inches pressure. If a polluted water be bacteriologically examined after passing through a few feet of such a filter the number of lactose fermenting organisms per c.c. will often show little change but the application of M'Conkey's tests shows that the lactose fermenting organisms present are not the same as those originally found in the polluted water. Two organisms are constantly present in ground water after percolating through the Colombo laterite formation. Both ferment lactose, saccharose, dulcite, adonite, and give Vosges Proskauer's reaction. One of them gives a marked indol reaction. Both are frequently found in the Labugama reservoir and in the town water-supply. Colombo well waters usually contain a trace of nitrates ; some of this is doubtless often due to recent organic pollution. I find however that nitrites are often present in association with nitrates, in samples of cabook soil which had been protected from all possibility of pollution for years. The nitrate is probably reduced to the nitrite by iron in the ferrous state contained in the soil.

It is therefore probable that in the case of water which has percolated through cabook the presence of nitrites is more often significant of old than of recent pollution, and is to be associated with the presence of nitrate. The results of chemical analysis of these waters, particularly the albuminoid ammonia figure, if interpreted on the usual line, indicate usually a much higher degree of organic contamination than the results of their bacteriological examination. Filtration through cabook and storage underground apparently diminishes the fæcal organisms and effects

a much greater improvement in the bacteriological than in the chemical condition of the water.

Water containing a trace of added nitrate, and giving no reaction with the alpha-naphthylamine test in three hours, if shaken up with powdered nitrite-free cabook, and allowed to stand overnight at room temperature, showed marked nitrites on the following day. Similarly, nitrated water after filtration through a sterile cabook soil, containing only a trace of nitrite, showed a great increase in the amount of nitrites as evidenced by the speedy appearance of the red colouration after addition of Griess's reagent.

The interpretation of the results of the bacteriological examination of open surface well waters dug in a porous soil is a matter of considerable difficulty. In Colombo the ground water as a whole constitutes a vast storage reservoir, receiving additions of polluted surface water after every fall of rain, purified to a variable extent by filtration through the soil. The question arises, however, whether open wells are ever to be regarded as free from the possibility of dangerous accidental pollution, however well constructed. It is necessary always to bear in mind that such pollution, as is found to occur in wells dug in the vicinity of human dwellings, is likely to be derived from human fæces, and is therefore very significant in character. The recent researches of Houston on the viability of uncultivated typhoid bacilli, the increasing recognition of the danger of the peregrinations of the typhoid and cholera carriers, have increased, relatively, the importance to be attached to recent as opposed to remote contamination, and have increased the need for the exercise of scrupulous care in safeguarding drinking waters from pollution of human origin. It is becoming increasingly difficult to lay down any hard and fast standards for the interpretation of the results of the bacteriological examination of water. It is quite certain that a judgment founded on the result of chemical or bacteriological examinations taken by themselves will often be entirely misleading.

Chemical analysis is capable of affording us valuable information as to the amount of labile organic matter in water. From a consideration of the relative amounts of oxydised and unoxydised nitrogen and of the available oxygen, we are often enabled to distinguish between old and recent pollution. The much more sensitive bacteriological method enables us to estimate fairly accurately the amount of fæcal pollution and to form some idea of its age. It is however only by the actual isolation of the specific organisms of a water-borne disease such as cholera or typhoid, that we are enabled to absolutely condemn a water on the strength of laboratory tests, without taking any other factors into consideration. Quite recently I have succeeded in isolating a vibrio, probably the vibrio of Asiatic cholera, from a canal within the city of Colombo. The organism is being made the subject of an extended investigation. The great weakness of our present methods for the analysis of water lies in the absence of any chemical or bacteriological test for human excrement as distinguished from the excrement of the lower animals. All experienced water analysts agree that it is unsound to express an opinion on the fitness of water for human consumption without giving the fullest weight to topographical considerations. Having found evidence of fæcal pollution in water, it is necessary to know from what sources it is likely to be derived, and whether there is any possibility of its being of human origin. Careful consideration of meteorological and geological data will often suggest a method by which the real significance of the pollution can be made apparent, *e.g.*, the application of a fluorescin test for the detection of fissures in the rock, or a series of bacteriological examination under different climatic conditions. As an example of the influence of topographical considerations on the interpretation of the results of a bacteriological analysis, I will give the results of two analyses.

(1) A sample of water taken at the mouth of a small flooded stream entering the Labugama reservoir, 28th May 1913. The stream in question yields very little water except during heavy rains. Number of colonies per c.c. 1536, No. of B. coli per c.c. 100. All the organisms isolated were either B. coli communis or B. neapolitanus. Streptococci were found.

(2) Well water. Number of colonies per c.c. 268; No. of B. coli, 1 per c.c., all the organisms isolated were B. coli communis. No streptococci were found.

Both these samples show evidence of recent pollution, the first being much more grossly contaminated than the second. The stream from which the first sample was derived runs its whole course through impenetrable jungle. In the absence of evidence that monkeys, and other fauna of the jungle, suffer, under primeval conditions, from diseases communicable to man, I should pass the sample as fit for human consumption, after a few days' storage to enable the suspended matter to deposit.

The second sample shows a much smaller amount of pollution than the first. Pollution however is not only recent but probably of human origin. I should condemn the water without hesitation.

I consider that at the present moment it is much more important to come to some agreement as to the selection of standard methods for the bacteriological

analysis of different classes of water, than to discuss the standards which should be applied to the results of a number of different methods. Numerical standards are perhaps most applicable to the results of bacteriological analyses for the control of filtration works, or to the results of the analyses of waters whose bacteriology has been closely studied. Even here the standard to be adopted will probably need to be specially adapted to the particular water, and to be varied at different seasons of the year. In the present state of our knowledge the selection of a practical method must largely depend on the resources of the laboratory, on considerations of economy, and on the importance to be attached to the results of any particular analysis. Where every item of evidence obtainable from the analysis of one set of samples is required it is advisable to employ a number of methods for estimating the degree of self-purification. The following may be instanced :—The estimation of the acid and gas line in lactose and glucose bile salt broth and liver broth by the decimal dilution method after 24 hours, 48 hours, and 72 hours; the determination of the acid and gas line in lactose before and after rejuvenation in glucose or glycogen media; the comparison between the number of B. coli commune, " lagin coli " and fæcal organisms of all sorts, or between the acid and gas line in lactose bile salt broth after 24 and 48 hours incubation; and the number of red colonies on glucose—neutral red, bile salt, agar of appropriate reaction. These tests require to be combined with the detailed study of the lactose and glucose fermenters to enable us to form an estimate of the degree of self-purification. These methods are strictly speaking only applicable to surface waters. In cases where part of the water in question has percolated through a porous soil, it is important not to overlook the possible influence of the soil bacteria, as has been pointed out by Clemesha. It must not be forgotten that surface water in its passage through long lengths of piping is liable to undergo bacteriological change, particularly in the number or organisms per c.c. growing on agar or gelatine. This is particularly noticeable in the case of pipes lined with a friable incrustation of organic matter as is often the case in Colombo.

For the ordinary purposes of routine bacteriological water analysis it is usually sufficient to perform the following tests :—

A count of the number of colonies on agar at 37° C. I have experienced difficulty, like Clemesha, in counting agar plates on account of the overgrowth of spreading colonies, but the difficulty does not appear to be so serious in Ceylon as in some parts of India, and can be largely overcome by counting at the end of 24 hours instead of 48. A count of the number of red colonies per c.c. growing on neutral red glucose bile-salt agar in 24 hours at 37° C. The isolation of ten colonies from a tube of lactose bile-salt broth containing 25 to 50 c.c. of the water on a plate of neutral red lactose bile agar : subsequently testing these organisms for indol, Vosges Proskauer's reaction, and the fermentation of saccharose, dulcite, and adonite. The estimation of the number of lactose fermenting bacilli per c.c. by the decimal dilution method in lactose bile-salt broth, recording the results after 24, 48 and 72 hours in the incubator at 37° C. If the incubator space be limited, the latter reading may be omitted. Whenever there is reason to suspect recent contamination a search for streptococci in the centrifugalised deposit from the water should be made. For the purpose of testing the efficiency of a filter it is usually sufficient to isolate five red colonies from the lowest three dilutions giving marked acid and gas in lactose broth within 48 hours, and to test them for indol, and to count the colonies on ordinary and on neutral red glucose bile-salt agar.

The work throughout having been carried out on a comparatively small scale, I have not been able to utilise the results of such a large number of analyses as the principal workers in this field. Nevertheless, I trust that the pains taken to secure accuracy may to some extent compensate for lack of data.

REFERENCES.

1. M'Conkey, A. Lactose Fermenting Bacteria in Fæces. (Journal of Hygiene, 1905.)
2. Fourth report Wellcome Tropical Research Laboratories at the Gordon Memorial College, Khartoum.
3. Journal of Infectious Diseases, 1911.

TABLE I.

Analyses of Labugama Tank Water, 1913.

			Series No. 1.	Series No. 2.	Series No. 3.	Series No. 4.	Series No. 5.
Date of Sampling ..			6-2-13.	15-4-13.	28-5-13.	22-9-13.	6-11-13.
Rainfall.	Previous 3 days		..	1·68	4·88	..	·52
	Previous 30 days		14·13	10·92	16·47	3·44	18·11
Weather			Cloudy.	Sunny.	Cloudy.	Sunny.	Cloudy.
Number of Organisms per c.c.	On Agar 48 hours at 37° C.	Surface	87	12	36	25	41
		Middle	188	150	348	14	693
		Deep	192	62	214	16	244
	On Neutral Red Bile Salt Lactose Agar 24 hours at 37° C	Surface	9	..	6	3	4
		Middle	60	43	107	..	115
		Deep	62	3	32	2	23
"Lagin" Coli in.		Surface	10 c.c.	10 c.c.	1 c.c.	*Nil* in 50	1 c.c.
		Middle	1 c.c.	1 c.c.	·1 c.c.	*Nil* in 50	10 c.c.
		Deep	1 c.c.	10 c.c.	·1 c.c.	*Nil* in 50	1 c.c.

TABLE II.

ANALYSES OF LABUGAMA TANK WATER, 1913.

Lactose Fermenters from 50 *c.c.*

Surface.

	6th February 1913.										15th April 1913.										28th May 1913.										22nd September 1913.										6th November 1913.									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Motility ..	+	+	+	−	+	−	−	+	+	+	−	+	−	+	+	+	+	+	−	+	+	−	−	+	+	−	+	+	−	−	−	−	−	−	−	+	+	−	−	−	+	−	−	+	+	+	+	+	+	−
Indol ..	−	−	+	−	+	−	−	+	+	−	+	+	+	+	+	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+
V. & P. ..	+	+	−	+	−	+	+	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	+	+	+	−	+	+	+	−	+	+	+	−	−	−	−	−	−	−	−
Saccharose ..	+	+	−	+	−	+	+	−	−	+	+	−	+	−	−	−	−	−	+	+	−	+	+	+	−	−	+	+	−	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	+
Dulcite ..	−	−	+	−	+	−	−	+	+	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	+	+	−	−	+	+	+	+	+	+	+	+
Adonite ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	+	−	−	−	−	−	−
Inuline ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

Middle.

	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Motility ..	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	+	+	−	+	+	−	+	+	+	−	−	−	−	−	+	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−
Indol ..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−
V. & P. ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	−	−	+	−	−
Saccharose ..	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	+	−	−	−	+	+	+	+	+	−	+	+	+	+	+	+	+	−	−	+	+	+	−	+
Dulcite ..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	−	+	+	+	+	+	+	+	+	+	+	+
Adonite ..	−	−	−	−	−	−	−	−	−	−	−	+	+	+	−	+	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	+	−	+	−	+	−	−	−	−	−	−	−	−	−	−
Inuline ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

Bottom.

	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Motility ..	+	+	+	+	+	+	−	−	+	+	−	−	−	−	−	−	−	−	−	−	+	+	+	−	−	+	+	+	+	+	+	−	−	+	+	−	−	+	+	+	+	−	+	+	+	−	−	−	+	+	+
Indol ..	+	+	+	+	+	+	+	+	+	+	+	−	+	−	+	+	−	−	−	−	−	−	+	+	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−
V. & P. ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	−	+	−	−	+	−	−	−	−
Saccharose ..	−	−	−	−	−	−	+	+	−	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	−	+	−	−	+	+	−	−	+
Dulcite ..	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	+	+	−	−	+	+	+	+	+	−
Adonite ..	−	−	−	−	−	−	−	−	−	−	−	+	−	+	−	−	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Inuline ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−

TABLE III.

Analyses of Labugama Tank Water.

Acid and Gas Line in Glucose and Lactose. M'Conkey Broth.

6th February 1913.

	Surface.						Middle.						Bottom.					
	Lactose.			Glucose.			Lactose.			Glucose.			Lactose.			Glucose.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
50 c.c.	++			++			++			++			++			++		
10 c.c.	+++	+		+++	+		+++	+		+++	+		+++	+		++		
5 c.c.	+++	+++		+++	+++		+++	+++		+++	+++		+++	+++		+++	+++	
1 c.c.	+++	+++		+++	+++		+++	+++		+++	+++		+++	+++		+++	+++	
·3 c.c.	++	+	−	+++	+		+++	+++		+++	+++		+++	+++		+++	+++	
·1 c.c.	+	−	−	+++	−		+++	+++		+++	+++		+++	++		+++	+++	
·03 c.c.	−	−	−	+	−	−	+	+	−	+++	+++		++	+	−	+++	+++	
·01 c.c.	−	−	−	−	−	−	++	−	−	−	−	−	+	−	−	++	+	−
·003 c.c.	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−
·001 c.c.	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−

15th April 1913.

50 c.c.	++			++			++			++			++			++		
10 c.c.	++	+		++	+		++			++			++			++		
5 c.c.	+++	++		+++	++		++	+		++	+		++	+		++	+	
1 c.c.	−	−	−	−	−	−	+++	+++		+++	+++		+++	+++		+++	+++	
·3 c.c.	+	−	−	−	−	−	+++	+++		+++	+++		++	−	−	+++	+	−
·1 c.c.	−	−	−	−	−	−	++	+	−	++	+		+	+	−	++	+	−
·03 c.c.	−	−	−	−	−	−	+	−	−	+	−	−	−	−	−	−	−	−
·01 c.c.	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−
·003 c.c.	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
·001 c.c.	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

28th May 1913.

50 c.c.	++			++			++			++			++			++		
10 c.c.	+++	+		+++	+		++			++			++			++		
5 c.c.	+++	++		+++	++		+++	+		+++	+		+++	+		+++	+	
1 c.c.	+++	+		+++	++		+++	++		+++	+++		+++	+++		+++	+++	
·3 c.c.	++	+	+	++	+	−	+++	+++		+++	+++		+++	+++		+++	+++	
·1 c.c.	−	−	−	++	−	−	+++	+++		+++	+++		+++	+++		+++	+++	
·03 c.c.	+	−	−	++	+	−	+++	+++		+++	+++		+	+	−	+++	+++	
·01 c.c.	−	−	−	−	−	−	+++	+++		+++	+++		++	−	−	+++	+++	
·003 c.c.	−	−	−	−	−	−	+	−	−	++	+	−	−	−	−	++	−	−
·001 c.c.	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

6th November 1913.

50 c.c.	++			++			++			++			++			++		
10 c.c.	++			++			++			++			++			++		
5 c.c.	+++	++		+++	++		+++	++		+++	++		+++	++		+++	++	
1 c.c.	+++	−		+++	++		+++	++		+++	+++		+++	+++		+++	+++	
·3 c.c.	+	−	−	+++	+		+++	++		+++	+++		+++	+		+++	+++	
·1 c.c.	−	−	−	++	+	−	+++	+		+++	+++		++	+	−	+++	+++	
·03 c.c.	−	−	−	+	−	−	+	−	−	+++	+++		+	+	−	+++	+	
·01 c.c.	−	−	−	−	−	−	−	−	−	+++	−		−	−	−	−	−	−
·003 c.c.	−	−	−	−	−	−	−	−	−	−	−	−	++	−	−	−	−	−
·001 c.c.	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−

Note.—++ = Acid and Gas in 24 hours.
\+ = Acid and Gas in 72 hours.

TABLE IV.

Characters of Lactose Fermenting Bacilli isolated from Normal Human Fœces.

Name of Organisms or Number in M'Conkey's List.	Number isolated.	Percentage of Total.	Motility.	V. & P. reaction.	Indol.	Saccharose.	Dulcite.	Adonite.	Inuline.
B. grunthali	18	7·2	+	−	++	−	−	−	−
B. vesiculosus	18	7·2	−	−	++	−	−	−	−
B. acidi lactici	10	4·0	−	−	++	−	−	+	−
B. coli mutabilis	4	1·6	−	−	−	−	−	−	−
B. coli communis	106	42·4	+	−	+	−	+	−	−
B. Schäfferi	7	2·8	+	−	++	−	++	−	−
No. 71	23	9·2	+	−	++	++	++	−	−
B. neapolitanus	13	5·2	−	−	++	++	++	−	−
Not listed	12	4·8	+	+	+	+	+	+	−
Carried over ..	211	84·4							

TABLE IV.—*continued.*

Names of organisms or Number in M'Conkey's List.	Number isolated.	Percentage of Total.	Motility.	V. & P. reaction.	Indol.	Saccharose.	Dulcite.	Adonite.	Inuline.
Brought forward ..	211	84·4							
No. 66	5	2·0	−	−	+	+	+	+	−
No. 67	5	2·0	−	+	−	+	+	+	−
No. 74	3	1·2	+	−	−	+	+	−	−
B. Friedlander	2	0·8	−	−	−	+	+	+	−
B. coscoroba	10	4·0	−	−	+	+	−	−	−
Not listed	8	3·2	−	+	+	+	−	+	−
B. cloacæ	4	1·6	−	+	−	+	−	−	−
B. lactis aerogenes	2	0·8	−	+	−	+	−	+	−
TOTAL ..	250	100·0							

Note.—All these bacilli were isolated by direct plating of an emulsion of the fæces on neutral red bile salt lactose agar. All colonies were picked off plates containing not more than 30 entirely discrete colonies; and tested for acid and gas in lactose broth.

TABLE V.

SUNLIGHT EXPERIMENT NO. 4.

Lactose Fermenters in 25 c.c. of 5 per cent. diluted sewage.

	Test No. 1. 12-30 P.M. 19-8-13.										Test No. 2. 1-10 P.M. 19-8-13.										Test No. 3. 2-25 P.M. 19-8-13.									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Indol	+	+	+	−	−	−	−	−	+	−	−	−	+	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−
V. & P.	−	−	+	+	+	−	+	+	−	+	−	+	−	+	+	+	−	+	+	+	−	+	+	+	−	+	−	+	+	
Saccharose	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Dulcite	−	+	−	+	−	+	+	−	−	−	−	−	+	−	+	−	+	−	−	−	−	−	−	+	−	+	−	+	−	−
Adonite	+	+	+	+	+	−	+	+	−	+	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	−	+	+	−	+
Inuline	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

	Test No. 4. 3-45 P.M. 19-8-13.										Test No. 5. 5 P.M. 19-8-13.										Test No. 6. 12-30 P.M. 20-8-13.									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Indol	−	−	−	−	−	−	−	−	−	−	−	+	−	−	+	−	−	−	+	+	+	+	−	−	+	−	+	+	−	−
V. & P.	+	+	+	−	+	+	+	+	+	+	−	−	+	+	−	+	+	+	−	−	−	−	+	+	−	+	−	−	−	−
Saccharose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	+	−	−	−	−	+	+	+	+	−	+	+	+
Dulcite	+	−	+	−	+	+	+	−	+	−	+	+	−	−	−	−	−	−	+	+	+	+	−	−	+	−	+	+	−	+
Adonite	+	−	+	−	+	+	+	−	+	−	+	+	−	−	−	+	−	−	−	−	−	−	+	−	−	−	−	−	+	+
Inuline	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

	Test No. 7. 2-30 P.M. 20-8-13.										Test No. 8. 4-30 P.M. 20-8-13.										Test No. 9. 12 A.M. 21-8-13.									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Indol	+	+	+	+	+	−	−	−	−	−	−	−	+	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−
V. & P.	+	−	−	+	−	+	+	+	+	+	+	+	+	−	+	+	−	−	+	+	+	+	+	+	+	+	+	+	+	+
Saccharose	+	+	−	+	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Dulcite	−	+	−	−	+	+	+	−	−	−	−	−	−	+	−	−	+	−	−	+	−	−	−	−	−	−	−	−	−	−
Adonite	−	+	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
Inuline	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

	Test No. 10* 12 A.M. 22-8-13.										Test No. 11. 12 A.M. 26-8-14.									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Indol	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
V. & P.	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Saccharose ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Dulcite	+	+	+	+	+	+	+	+	+	+	+	−	+	+	−	−	+	+	+	−
Adonite	−	−	−	−	−	−	−	−	−	−	−	+	−	−	+	−	−	−	−	+
Inuline	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

Note.—Average temperature during exposure of the emulsion to sunlight 38°C.

* The Bacillus isolated in Test 10 was feebly motile. It produced a bubble of gas and a little acid in Saccharose Broth in five days.

EXPERIMENTS IN THE FILTRATION OF WATER THROUGH SLOW SAND AND MECHANICAL FILTERS, AT THE KING INSTITUTE, GUINDY, MADRAS.

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OBJECT OF THE EXPERIMENTS.

IN the Madras Presidency about five years ago there were five water-works at which the water supplied to the towns was first filtered through slow sand filters.

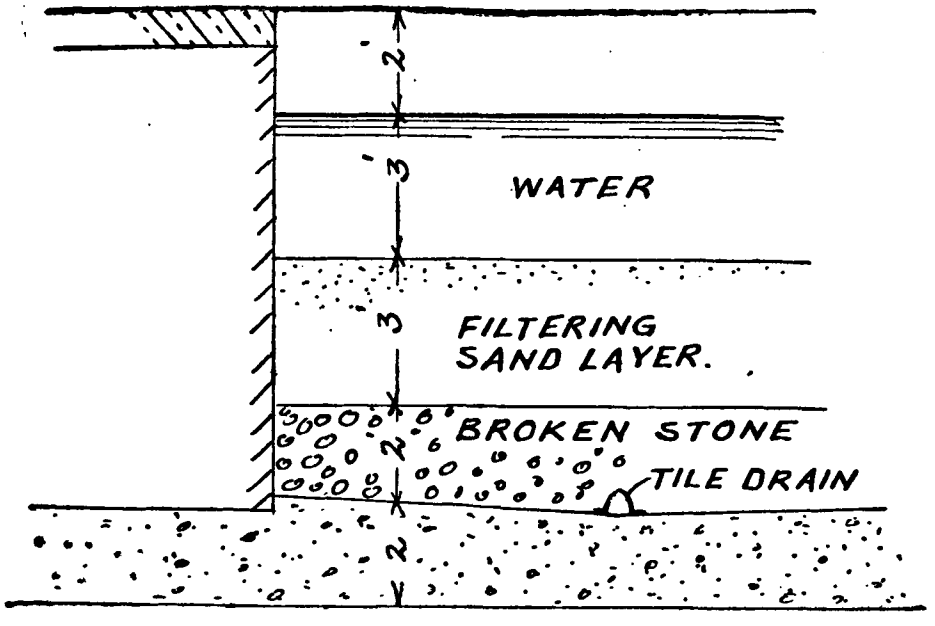
A new system of water analysis was at this time introduced at the King Institute of Preventive Medicine, Guindy, and arrangements were made to obtain quarterly samples of water from the different water-works in the Presidency including the five works at which the filtration was through slow sand filters.

These samples were taken by a peripatetic sample-taker of the grade of Sanitary Inspector who made regular quarterly tours throughout the Presidency and forwarded the water samples or conveyed them personally to the King Institute for analysis by the staff of that Institute. In those cases where the sample-taker had to take samples from several water-works during the same tour the samples first taken were packed in ice and forwarded by the first passenger train. The results of the analyses obtained were communicated with the remarks of the Director of the King Institute and the Sanitary Commissioner to the Local Bodies concerned and to the Sanitary Engineer to Government for necessary action being taken to improve matters where the results showed this was necessary.

The results obtained were of an unexpected character. As a general rule the filtered water was bacteriologically shown to be worse than the unfiltered water and it was discovered that leakage of sub-soil water was occurring into the filter beds presumably by diffusion and into the filtered water reservoir by actual leakage.

In addition to these defects it was reported that the design of filter beds adopted in the Madras Presidency was radically wrong. The design adopted followed the usual European standard design of filter bed consisting of a broken stone layer 2 feet thick super-imposed by 3 feet depth of filtering sand.

The following sketch shows a type section of the filter beds in use.



It was stated the design of filter bed adopted in Madras was unnecessarily expensive and that the following alterations would not only reduce the cost of a filte bed but would give much better bacteriological results from analyses of the filtrate

The safety margin 2 feet in the design above the water-level was declared to be excessive and with proper automatic control of the supply of raw water this margin of 2 feet could, it was said, be reduced to six inches.

It was also stated that the depth of water above the sand could in the first instance be reduced to 2 feet from 3 feet, the depth of sand from 3 feet to 2 feet 6 inches, and the broken stone layer from 2 feet to 1 foot. It was also stated that the extent of the broken stone layer and the post filtration passages were responsible for increase by multiplication in the number of bacilli per cubic centimeter and for the fact that the filtered water was of inferior quality bacteriologically to the unfiltered water of the storage tank or canal, the source of supply to the water-works.

It was found impossible to disprove the statements made and after due consideration, it was thought that it was possible that some alteration of the European standard design might be advisable in the high average temperature of the climate of the Madras Presidency.

The Government of Madras were subsequently advised to sanction the carrying out of experiments on a sufficiently large scale at the King Institute, Guindy, near Madras, and the proposals made were approved.

It was also decided to combine the experiments on slow sand filters with experiments on mechanical filters. The following works were thereupon constructed and were inspected, when under construction, by the delegates to the second All-India Sanitary Conference which was held at Madras in November 1912.

A pumping station consisting of 3 Worthington pumps and a Cochran boiler was erected on the right bank of the river Adyar at the King Institute, Guindy, Madras. From this pumping station one of the Worthington pumps pumped river water into two open masonry storage tanks each of 4 hours' capacity located on the high ground.

From the storage tanks water was led on to two slow sand filters each 9 feet square and a second connection led water from the storage tanks to two alumina houses whence it flowed, after receiving a dose of sulphate of alumina, into two coagulating tanks. One of these tanks supplied a 4-foot Jewell Gravity Filter and the other a 5-foot Paterson Filter. The effluent from these mechanical filters was run into two clear water tanks whence it could be pumped by two independent Worthington pumps upwards through the mechanical filters when these filters required to be washed by their respective filter water effluents.

The mechanical filters on which experiments were intended to be carried out were the Jewell and the Paterson.

On the inlet and outlet of all the filters meters were provided for measuring the quantity of the water dealt with. The Jewell mechanical filter used was 4 feet in diameter and was arranged with a 12-foot filtering head on the suction principle and an efficient outlet controller. This filter was washed twice a day, the operation being performed by cutting off the inlet water and washing the sand bed from below by means of Jewell filtered water pumped by an independent Worthington pump. The sand bed was at the same time stirred by a mechanical geared rake worked by hand by turning a handle.

The Paterson Filter was 5 feet in diameter and had a working head of 6 feet. It was washed by filtered water from below supplied by an independent Worthington pump, and in lieu of the mechanical rake in the Jewell Filter the sand bed was stirred from below by means of an air blast induced by a steam injector. The filter outlet was regulated by an ordinary float valve and ball arrangement.

The Slow Sand Filters provided at the experimental works were two in number. Of these one was constructed similar to the Madras standard as illustrated above.

The second experimental filter was constructed as shown on next page :—

Each filter was provided with a ball valve regulating inlet, but as the automatic outlet regulator required alteration the outlet was subsequently operated by an ordinary stopcock. To enable samples to be taken from different depths in each filter so as to show the effect of the filtering material on the quality of the water, ½ inch test cocks were inserted in each filter side wall and numbered from 1 to 6. No. 1 cock gave a sample of the unfiltered water on the top of the sand layer. In the side wall of each slow sand filter a plate glass window from the floor-level to just above water-level was built in for inspection purposes.

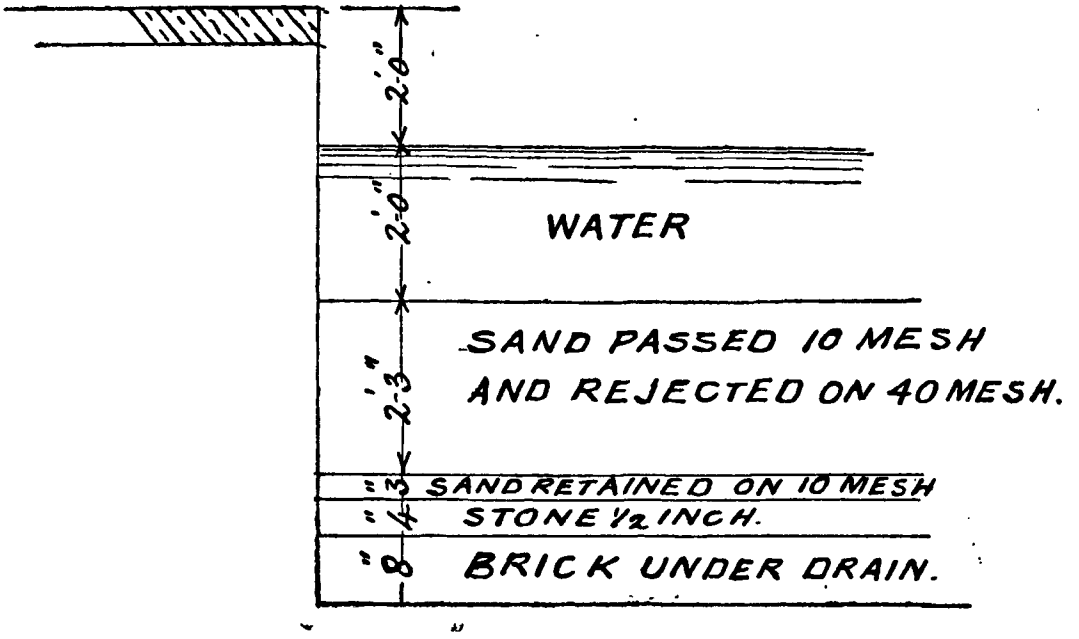
It was subsequently found necessary to place a removable wooden shutter in front of each inspection window, when not in use, in order to exclude light as it was found that algæ began to grow in the filtering material as soon as water was let into the filters.

The filters were started working on the 1st March 1913, and the results are shown in an appendix to this paper.

The samples of water were carefully taken from test cocks, one ½ inch cock being provided at each place where a sample had to be taken. The results obtained from the analyses show considerable variation which it is impossible to account for.

In some cases the filtered outlet water showed a less degree of purity than the test tap at the bottom of each filter. This was considered to be due to the fact that

the filtered water chambers covers were not dust-tight and under the arrangement made they had to be removed daily in order to manipulate the outlet valve in order to increase the filtering head.



The general results show that both the slow sand filters give satisfactory results and if anything the advantage is with the Madras standard filter. The results of analyses of samples from the test cocks in the side walls of the filters show a tendency to continued bacteriological improvement as the water passes downwards through the layers of filter bed materials and therefore show that the former contention that the filtered water decreased in quality as it passed through the underlayers is not borne out by the results obtained at Guindy. This seems to be a natural result, as the general belief is that the greater the depth through which surface water passes in sand and gravel, the better the quality of the water so obtained.

In sewage bacterial filters the purification of the sewage in those filters is obtained from its passage through a depth of broken stone or other similar material. This being so, it is thought that the passage of water through the broken stone underlayers of a sand filter results in better quality of the effluent. The same principle is followed in the Puech-Chabal system of water purification and if the statement that water decreased in quality in its passage through broken stone underlayers of a sand bed filter was correct, apparently the operations which go on in a Puech-Chabal Filter would be radically wrong in principle. But it is believed that the contrary is true, *viz.*, that water in passing through the gravel beds of a Puech-Chabal installation improved in quality bacteriologically. It is therefore thought that the passage of water through the broken stone underlayers of a sand filter does not render that water less bacteriologically pure and the explanation why bad results were obtained from analyses of filtrates from municipal water-works filters in Madras Presidency can be explained in a less scientific way, *viz.*, the decrease of quality was simply due to the contamination of the water by impure sub-soil water which leaked into the filter beds through cracks in the masonry.

In the Guindy experiments the water dealt with was highly impure and it would not have been used for a permanent water-works without prior storage and settlement in a tank of large capacity or after double filtration. The filter beds were therefore put to a more severe test than they would be put to in water-works on the usual large scale.

In addition, the small size of the filters used, 9 feet square, was a severe test of the results as the proportionate length of walling permitting water creepage was very high when compared with a filter of say the size of a Madras City filter. The length of walling in each experimental filter at Guindy was 36 feet and the filtering area 81 square feet. In the Madras City filter, which is of dimensions 200 × 100, the length of walling is 600 feet and the area for filtration 20,000 square feet. The chances of contamination due to water creepage in an experimental filter at Guindy is therefore 15 times greater than in the case of the Madras City filters. The possibility of water creepage in mechanical filters is much greater than in a slow sand filter unless special precautions are taken to avoid it.

The experiments carried out at Guindy have shown conclusively that in an uncovered filter the depth of water should not be reduced as originally proposed.

In the filter in which only 2 feet of water was kept above the sand layer the growth of algæ on the surface of the sand and in the water was very great. It was

less in the other filter where the depth of water was 3 feet or 1 foot more than in the filter where the growth of algæ was most noticeable.

The experiments show that in Madras the depth of water should not be less than 3 feet and it would be better to make it 4 feet. To do this the free margin of 2 feet could be reduced to 1 foot which would be usually sufficient if suitable working automatic valves not likely to easily get out of order were provided on the inlet of a filter with the usual safety overflow arrangement.

Working Period of the Filters.

The working period of the slow sand filters was less than was expected, and it is considered that this was due partly to the quality of the water which, although usually clear, deposited a slimy layer of considerable density in a comparatively short time. The longest period between scrapings was about 21 days.

The filtering layer of sand was made of sand which passed through a sieve of 100 meshes to the square inch and was retained on a sieve of 1,600 meshes to the square inch.

This is considered to be the maximum fineness of filtering sand in ordinary circumstances when the raw water has been efficiently settled. This conclusion is strengthened from an experiment which was carried out on one of the filters. On this filter the 3 inches of sand which had been removed in working were replaced by a layer of 3 inches of sand which was only retained on a sieve of 6,400 meshes to the square inch.

This filter was found to clog up rapidly and the maximum head of 24 inches was reached in the short period of 10 days, thus showing the result of using sand which is too fine for practical working, however high the bacteriological results of tests of the filtrate may be.

It is considered that the sand should be as coarse as will permit the formation of a slimy layer covering each grain of sand and the space between adjoining grains so effectively that the slimy layer will not be pierced by raw water under the starting working head of ½ inch nor subsequently by an increased head up to 24 inches, the usual maximum. The experiments at Guindy show that the coarser sand while giving good bacteriological results, also allows of the working of the filter for a longer period than is obtained when finer sand is used.

Disturbance of the 'Slimy Layer' in a slow Sand Filter.

It has always been considered that the disturbance of the slimy layer of a slow sand filter would adversely affect the working of that filter. This belief was strikingly confirmed in the Guindy experiments. Although the smaller frogs which frequent slow sand filters were easily caught and removed from the filter without disturbing the working, on one occasion it was found that 3 or 4 large green frogs about 5 inches long, when not extended, had invaded the filters. Endeavours to net these frogs proved futile and it was found that in escaping these frogs bored into the sand layer. The working head on the filters before this occurred was 10 inches and this head immediately fell to 2 inches, showing that holes had been made in the slimy layer.

An experiment was then made by removing the earth so that there was left a vertical wall 3 feet high around the filters. This was found to effectually exclude the frogs not only the large but also the smaller ones. It seems therefore necessary in slow bed filter design to have a permanent masonry wall 3 feet high immediately around the filters.

Depth of Sand.

Although the results obtained from the filter in which the depth of sand was only 2′ 6″ instead of 3 feet as in the other filter were on the whole satisfactory, still it is not considered that the depth of sand in any slow sand filter should be less than 3 feet when the filter is first started and it is advisable to have the depth of sand 3′ 6″ in thickness. The latter thickness would allow of "scrapings" taking place until the depth had been reduced to 2′ 6″ when the 1 foot of sand would be replaced by fresh sand or by the old sand after thorough washing in a sand washer. If the filter bed was originally started with only 2′ 6″ of sand, either the sand would require renewal after 6 inches had been removed, which would mean interruption of working for some time while this was being done, or if the sand bed was scraped until 1 foot had been removed, it would mean the depth of the sand bed would be reduced to 1′ 6″ or 6 inches less than the minimum of 2 feet thickness which is our standard.

It is consequently considered that the thickness of the sand layer in a slow sand filter should not be less than 3 feet when the filter bed is first brought into use after sand filling has been completed.

Depth of the Broken Stone Underlayers.

The proposal made to reduce the depth of the broken stone underlayers from 2 feet to 1 foot was probably made on the assumption that almost the whole of the

purification of water in a slow sand filter was obtained when the water was passed through the slimy layer on the top of the sand. Such a view might lead one to suppose that an excessive depth of broken stone under the sand layer would be detrimental to the quality of the water which had passed through the slimy layer and the sand bed underneath it.

The results of the analyses of samples from different depths of the sand filters at the Guindy Experimental Works, while they might have been more in number and therefore more conclusive, show a tendency in the opposite direction to the opinion expressed condemning the excessive thickness of the broken stone underlayers. The results point to a progressive improvement in quality as the water passed through the sand and the broken stone underlayers.

Such a result can be expected when it is remembered that sewage is purified by passing it through bacterial filters of broken stone and the experience at the Rochdale Sewage Works points, it is believed, to the increased benefit obtained by increasing the depth of such bacterial filters from 5 or 6 feet to 9 feet. The conclusion arrived at is that water is not reduced in quality by passing it through the broken stone underlayers of a sand bed filter and consequently the depth of these layers need not be reduced in thickness with the object of avoiding a reduction in quality when filtered water passes through them. This opinion is supported by the universal practice of providing a considerable depth of sand in a sand filter. If there were no improvement in quality of the water in passing through the sand bed, then, it would be unnecessary to have this bed any thicker than say a few inches which would be sufficient to support the slimy layer.

MECHANICAL FILTERS.

Jewell Filter.

The Jewell Filter used in the experiments at Guindy was 4 feet in diameter and was guaranteed to filter 30,000 gallons of water daily. The water from the small storage tanks was run into a channel below the Alumina House which contained a wooden tub in which the coagulating chemical, sulphate of alumina, was dissolved. The house also contained a ball tap regulating arrangement and the well-known Jewell vulcanite distributing pipe and cocks for minutely regulating the supply of dissolved sulphate of alumina according to the number of grains of sulphate of alumina required to produce the requisite slimy layer on the filter after the water had passed through a coagulating tank for mixing and deposition purposes.

The experiment was first started with one grain of sulphate of alumina added per gallon of water to be filtered as the river water was not turbid and only cloudy in appearance. The quantity of alumina was subsequently increased to $1\frac{1}{2}$ to 2 grains per gallon as the reduction in the number of bacteria was found to be insufficient. It is believed that, owing to the large number of bacteria in the unfiltered water, the quantity of sulphate of alumina must necessarily be increased above 1 grain per gallon if the filtrate is to show less than 100 bacilli per c.c.

The unfiltered water after the addition of the coagulating chemical, sulphate of alumina, passed over a weir into a coagulating tank of 4 hours capacity provided with 3 cross walls. The water passed under the first wall and over the second and under the third and then was conducted by a cast-iron pipe to the filter. This filter was of the usual Jewell pattern, but the raking gear owing to the small size of the filter was operated by hand. The supply to the filter was automatically regulated by a float valve and on the outlet there was the usual patent differential controller. Both in the Jewell Filter and in the Paterson Filter it was subsequently found that the outlet pipes which were provided by the department had been laid with insufficient fall and consequently the quantity filtered was less than expected. When this defect was rectified the discharge was equal to the guaranteed discharge.

Right through the experiment the Jewell Filter was found to be a good practical filter, giving no trouble in working.

Paterson Filter.

The Paterson Filter was 5 feet in diameter and was worked under a head of 6 feet. The coagulating apparatus differed from the Jewell in that it consisted of an iron trough containing two mixing compartments with two sets of ball valves. One of these sets was apparently intended for the addition of a second chemical besides the sulphate of alumina which it was intended to use. The ball valve apparatus was made of gunmetal or brass instead of vulcanite and consequently is not expected to last when exposed to the action of sulphate of alumina.

From the chemical mixing apparatus the water passes into an iron mixing trough provided with baffle plates and then into a similar coagulating tank of masonry to that provided for the Jewell Filter installation. From the coagulating tank the water passes to the Paterson Filter which consists of an iron tank 5 feet in diameter in which quartz gravel and filtering sand are placed. Underneath the

quartz gravel there is a number of outlet nozzles, a similar arrangement to the Jewell Filter, except that in the latter the copper gauze of the outlet nozzles is placed on each side of a nozzle, while in the Paterson arrangement it is horizontal and it has been said these are therefore more liable to be broken by pressure.

The water from the coagulating tank passes on to the surface of the sand in the filter and there deposits a slimy layer which during the working of the filter gradually increases until filtration is almost completely stopped. The outlet discharge of the Paterson Filter is controlled by a ball valve and float arrangement. The ball attached to the lever arm rests on the surface of unfiltered water in the filter tank and the other end of the lever is connected by a vertical rod to a float which is placed in the filtered outlet chamber and which controls the discharge of the filter. The apparatus is not nearly so sensitive as the patent Weston controller used in the Jewell Filter. During the working of the Paterson Filter it was noticed that it required frequent washing, as many as 3 washes a day being necessary. After some time it was considered that the reason for this early clogging of the filter was due to the fine sand used compared with that used in the Jewell Filter. It is not known why in the first instance the suppliers of the Paterson Filter sent the fine sand. On the matter being represented the same quality of sand as used in the Jewell Filter was afterwards sent and the Paterson Filter was then found to give the requisite quantity of filtered water.

In the Paterson Filter the principal difference between this type of mechanical filter and the Jewell Filter is the method of washing the sand of the filter.

In the Jewell Filter this washing is done by means of filtered water which is forced through the sand of the filter from below upwards, while at the same time the sand bed is mechanically raked. In the Paterson type instead of the mechanical rake the sand bed is agitated by an air blast from below. This air blast is produced by a steam injector.

The air blast operation is more interesting to watch, but it is found that the air blast does not pass around each grain of sand in the filter but passes upwards in a number of funnels or passages. This is quite a natural result to expect as the air blast must naturally follow the line of least resistance and the consequence is it does not agitate the whole of the bed but escapes at certain well defined areas. This statement has been made from an actual test of the filter when by lowering the water in it to the surface of the sand the escape of the air bubbles from it could be detected and the area agitated or non-agitated could be definitely determined. It is considered that however interesting the action of the air-wash may be to the onlooker, the mechanical rake is more positive in action. It seems to me that the ideal arrangement would be to combine the two methods in one filter.

Analyses.

The results of bacteriological analysis of the filtrates from both the Jewell and the Paterson Filter are shown in the appendix. Neither of the results approach those from the slow sand filter.

In addition to these results which were obtained at a time when the river water was clear, the same appendix shows results when the river water was turbid. This was for the period from 10th October 1913 to 31st October 1913.

During the period when the river water was turbid, the filtrate from the Jewell Filter (the Paterson was out of use) maintained its sparkling and clear condition, while the slow sand filters gave cloudy filtrates and decreased in quality from the bacteriological standpoint.

The Jewell Filter was washed in the usual way during the time the river water was turbid and the experience shows that mechanical filters are most efficient under this condition.

Conclusion.

The following is a statement of the conclusions arrived at from the results of supervision and tests of the storage tanks of the experimental slow sand filter and mechanical filters at Guindy, Madras :—

1. The provision of the open tanks for storage purposes which allow of a settlement of 8 hours' duration usually results in the reduction of the number of bacteria by 50% from the number contained in the raw river water pumped to the tanks.
2. That the results obtained from a slow sand filter of the usual standard design show that such a filter in the high average temperature of Madras is highly efficient when the raw water is fairly clear.
3. That when the raw water is turbid efficient settlement in storage tanks of ample capacity with or without the addition of a coagulant such as sulphate of alumina, is necessary to obtain good results.
4. That so far the results obtained at the experimental filters at Guindy show that an increased depth of broken stone underlayers does not tend to an increase in

the number of bacteria in the filtrate, but that on the contrary such increased depth tends to ensure more and not less efficient results.

5. That 3 feet is a suitable minimum depth for the sand bed of a slow sand filter when such filter is first started working.

6. That the grade of sand which should be used on a slow sand filter should be in relation to the turbidity of the water to be filtered, and that for practical reasons it is advisable to use as coarse a sand as will give a filtrate of the requisite bacteriological quality.

7. That the following grade of sand is generally suitable for slow sand filters for filtration purposes :—

" Sand which passes through a sieve of 10 meshes to the lineal inch and is retained on a sieve of 40 meshes to the lineal inch." If much finer sand than this grade is used, the life of the slow sand filter between periods of scraping is reduced in proportion to the fineness of sand to such an extent as to put the filter out of use for numerous periods separated by short intervals.

8. That the minimum depth of water on the top of the filtering sand layer should not be less than 3 feet, as a lesser depth encourages the growth of algæ on the surface of the sand and that a depth of 4 feet in the climate of Madras is advisable.

9. That in order to prevent the presence of frogs in the sand filters with consequent damage to the filtering medium, it is advisable to provide a vertical wall 3 feet in height around the filters.

10. That the safety margin of wall usually provided to a height of 2 feet above the level of water in the filters might with proper surplusing and automatic inlet valve arrangements be reduced to 1 foot as it is thought that this amount might provide for wave action in filters of ordinary size.

11. That mechanical filters have not shown from the Guindy experiments such satisfactory results as the slow sand filters during the periods when the unfiltered water was fairly clear.

12. That owing to the excellent results obtained from slow sand filters at Guindy, it seems advisable to prefer such filters provided the water to be filtered is fairly clear, this state being obtained, if necessary, by prior settlement in sufficient large storage tanks.

13. That in those cases where such settlement cannot be obtained or where the turbidity of the water is such as to resist settlement for a length of time exceeding 24 hours, the provision of mechanical filters is advisable.

APPENDIX I.

GUINDY EXPERIMENTAL FILTERS—SAND FILTER DATA.

C = Clemesha Filter. M = Madras Standard Filter.

Date.	Gallons filtered for 24 hours.		Filter Head, inches.		REMARKS.
	C.	M.	C.	M.	
1–8–13	4,050	4,000	1 5/8	1 1/8	
2–8–13	4,000	4,100	1 3/4	1 1/4	C. growth of algæ in Clemesha filter.
3–8–13	4,000	4,100	1 7/8	1 3/8	
4–8–13	4,050	4,100	2	1 1/2	
5–8–13	4,025	4,100	2 1/8	1 5/8	
6–8–13	4,025	4,100	2 1/4	1 3/4	
7–8–13	4,050	4,100	2 3/8	1 5/8	
8–8–13	4,000	4,000	2 1/2	1 3/4	
9–8–13	4,050	4,100	2 3/4	1 7/8	C. Inlet closed to lower W. L. to aerate at 8 P.M., when meter readings were inlet 489,150; outlet 397,100.
..	2,000	..	..	..	
10–8–13	..	4,100	..	1 3/4	C. outlet closed at 8 A.M., meter readings were 398,300, and inlet opened and filter started at 2 P.M.
11–8–13	3,050	4,100	..	1 7/8	
12–8–13	4,100	4,000	..	2	
13–8–13	4,000	4,000	1/4	2 1/8	Rain last night.
14–8–13	4,050	4,100	3/4	2 1/4	
15–8–13	4,050	4,100	7/8	2 1/2	
16–8–13	4,050	4,100	1	2 3/4	
17–8–13	4,050	4,100	1 1/2	3	
18–8–13	4,050	4,050	2 3/4	3 1/4	
19–8–13	4,050	4,000	3 1/2	3 1/2	
20–8–13	4,000	4,000	5	5	
21–8–13	3,975	4,000	9	8	
22–8–13	4,000	4,000	14	12	
23–8–13	4,000	4,000	20	16	
24–8–13	4,000	4,000	27	20	
25–8–13	3,200	4,050	27	24	Inlet closed at 8 A.M.
26–8–13	..	..	..	..	W. L. allowed to run down.
27–8–13	..	..	..	..	Ditto ditto.
28–8–13	..	..	..	..	C. slimy layer removed. M. not dried yet.
29–8–13	..	..	..	..	M. slimy layer scraped out.
30–8–13	..	..	..	..	M. 2″ of silted up sand removed.
31–8–13	..	..	..	..	C. 1″ of ditto ditto.
1–9–13	..	..	..	..	Filter beds exposed to sun.
2–9–13	..	..	..	..	Ditto ditto.
3–9–13	..	..	..	..	3″ of sand retained on 40 meshes laid fresh (washed) in M. S. F.
4–9–13	..	..	..	..	3″ of fine sand retained on 80 meshes laid fresh (washed) in M. S. F.
5–9–13	..	..	..	..	Filter beds levelled.
6–9–13	..	..	..	..	Filter beds exposed to sun.
7–9–13	..	..	..	..	Ditto.
8–9–13	..	..	..	..	Meters opened out, cleaned and refixed.
9–9–13	..	..	..	..	Inlet opened at 10 A.M.
10–9–13	..	..	..	..	Filters filled up to maximum level.
11–9–13	..	..	..	..	Filter beds are allowed to stand quiescent.
12–9–13	..	..	..	..	Outlet valves opened and filters started (Raw water is very turbid).
13–9–13	2,025	2,450	..	1/2	
14–9–13	3,500	3,000	..	1	
15–9–13	4,000	3,950	..	1 1/2	
16–9–13	4,000	4,050	..	2 1/2	
17–9–13	4,075	4,025	..	3 3/4	
18–9–13	4,050	4,025	1/4	6 1/2	
19–9–13	4,075	4,075	1/2	12	
20–9–13	4,050	4,075	3/4	18	
21–9–13	4,050	4,000	1	24	
22–9–13	4,050	3,750	1 1/2	24	M. stopped at 8 A.M. to-day (22-9-13).
23–9–13	4,050	..	1 3/4	..	Rain between 2-30 and 4 P.M.
24–9–13	4,050	..	2	..	
25–9–13	4,000	..	2 1/4	..	Rain on the previous night.
26–9–13	4,050 1/2	..	2 3/4	..	Slight drizzling last night. M. started at 7 A.M.

APPENDIX I—*concluded.*

Date.	Gallons filtered for 24 hours.		Filter Head, inches.		Remarks.
	C.	M.	C.	M.	
27-9-13	4,000	4,000	3½	..	
28-9-13	4,000	4,000	3¾	..	
29-9-13	4,075	4,000	4¼	¼	Rain; water very muddy.
30-9-13	4,025	4,025	4½	1½	
1-10-13	4,000	4,000	5	3	
2-10-13	3,900	4,000	6½	4½	
3-10-13	4,000	4,000	8	8	
4-10-13	4,000	4,000	10	14	
5-10-13	4,000	3,950	12	22	
6-10-13	4,000	3,825	14	24	Rain whole of last night and this whole day. River full of flood water; M. inlet closed.
7-10-13	4,100	325	16	24	M. stopped for cleaning.
8-10-13	4,100	..	18	..	M. allowed to dry.
9-10-13	4,100	..	10	..	M. slimy layer removed (owing to rain in C. F. Silty layer on the surface probably disturbed. Hence reduction in head).
10-10-13	4,100	..	8	..	M. started at 7-30 A.M. Heavy rain last night.
11-10-13	4,100	3,800	8	..	
12-10-13	4,100	3,900	6	½	Heavy rain last night.
13-10-13	4,100	3,900	5	1½	
14-10-13	4,050	3,900	5	3	
15-10-13	3,950	3,900	5	5	
16-10-13	4,000	3,950	6	6	
17-10-13	4,050	3,950	6½	9½	
18-10-13	4,050	4,000	7½	13	
19-10-13	4,050	4,000	8½	18	
20-10-13	4,000	4,000	9½	24	
21-10-13	4,000	3,250	10	24	M. stopped for cleaning at 8 A.M.
22-10-13	4,000	..	10½		Slimy layer scraped out and ¾" of silted up sand removed and bed exposed to sun.
23-10-13	4,100	..	11	..	
24-10-13	4,100	..	11½	..	M. started at 8 A.M. Rain from 2 A.M., day and night.
25-10-13	4,100	3,250	11	..	Rain whole day.
26-10-13	4,050	3,550	10	¾	Rain day and night.
27-10-13	4,100	3,850	9½	2	Rain in the previous day and night.
28-10-13	4,000	3,950	8	3½	Rain in the previous night.
29-10-13	4,100	3,900	8	6	Heavy rain and high floods in the river.
30-10-13	4,100	3,900	7	8	Ditto.
31-10-13	4,100	3,950	6½	9	Ditto.
1-11-13	4,050	3,950	6½	11	
2-11-13	4,100	4,050	7	13	
3-11-13	4,000	4,100	7½	18	
4-11-13	4,050	4,000	8	24	

APPENDIX II.

GUINDY EXPERIMENTAL FILTERS—MECHANICAL FILTER DATA.

J = Jewell Filter. P = Paterson Filter.

Date.	Quantity of water filtered per 24 hours.		Alumina used, grains per gallon of water.		Number of washes per 24 hours.		Percentage of wash water to filtrate for 24 hours.		Time taken for each wash.		REMARKS.
	J.	P.	J.	P.	J.	P.	J.	P.	J.	P.	
1-8-13	11,025	8,850	1½	1½	1	1	4·5	5·6	8 to 8-10 A.M.	8-10 to 8-20 A.M.	
2-8-13	13,100	11,600	1½	1½	1	1	3·8	4·3	Do.	Do.	
3-8-13	..	..	..	..	..	..	..	..	....	....	Coagulating tanks cleaned out.
4-8-13	14,700	12,750	1½	1½	1	1	3·4	3·9	8 to 8-10 A.M.	8-10 to 8-20 A.M.	
5-8-13	23,750	19,350	1½	1½	2	2	3·2	5·2	7-45 to 8 A.M.	8 to 8-10 A.M.	Both filters washed twice.
6-8-13	12,100	8,000	1½	1½	1	1	4·1	6·2	12 to 12-15 P.M.	12-15 to 12-30 P.M.	
7-8-13	14,185	12,400	1½	1½	1	1	3·5	4·0	11-30 to 11-40 P.M.	11-40 to 11-50 A.M.	
8-8-13	13,150	11,575	1½	1½	1	1	3·8	4·3	8 to 8-10 A.M.	8-10 to 8-20 A.M.	
9-8-13	13,100	12,225	1½	1½	1	1	3·8	4·1	Do.	Do.	
10-8-13	..	..	..	..	..	..	..	..	....	....	Coagulating tanks cleaned.
11-8-13	10,400	8,950	1½	1½	1	1	4·8	5·6	12 to 12-10 P.M.	12-10 to 12-20 P.M.	
12-8-13	12,300	12,050	1½	1½	1	1	4·1	4·1	7-45 to 7-55 A.M.	8 to 8-10 A.M.	
13-8-13	16,900	15,700	1½	1½	1	1	3·0	3·1	8 to 8-10 A.M.	8-10 to 8-20 A.M.	Rain on last night, 24 hours working with 1 wash.
14-8-13	16,400	11,825	1½	1½	1	1	3·0	4·2	Do.	Do.	J. allowed to work for 24 hours.
15-8-13	13,225	11,575	1½	1½	1	1	3·7	4·3	Do.	Do.	
16-8-13	13,350	11,600	1½	1½	1	1	3·7	4·3	Do.	Do.	
17-8-13	..	..	..	..	..	..	..	..	....	....	Coagulating tanks cleaned.
18-8-13	13,675	8,750	1½	1½	1	1	3·6	5·7	8 to 8-10 A.M.	8-10 to 8-20 A.M.	P. worked at a less rate as there was less water in the storage tank.
19-8-13	12,200	11,950	1½	1½	1	1	4·1	4·2	Do.	Do.	Drizzling.
20-8-13	13,580	12,100	1½	1½	1	1	3·7	4·1	Do.	Do.	Rain.
21-8-13	11,020	9,500	1½	1½	1	1	4·5	5·2	Do.	Do.	Rain water mixed up with silt and organic matter and is black.
22-8-13	12,100	11,300	1½	1½	1	1	4·1	4·4	Do.	Do.	
23-8-13	9,100	10,950	1½	1½	1	1	5·5	4·5	Do.	Do.	Supply was less to J. inlet.
24-8-13	..	..	..	..	..	..	..	..	....	....	Coagulating tanks cleaned out.
25-8-13	13,290	12,000	1½	1½	1	1	3·7	4·2	8 to 8-10 A.M.	8-10 to 8-20 A.M.	
26-8-13	13,350	12,475	1½	1½	1	1	3·7	4·0	Do.	Do.	
27-8-13	13,225	11,525	1½	1½	1	1	3·7	4·3	Do.	Do.	
28-8-13	11,525	10,750	1½	1½	1	1	4·3	4·6	Do.	Do.	
29-8-13	14,000	10,450	1½	1½	1	1	3·6	4·7	Do.	Do.	
30-8-13	13,300	9,350	1½	1½	1	1	3·7	5·3	Do.	„	
31-8-13	..	..	..	..	..	..	..	..	....	....	Coagulating tanks cleaned out.
1-9-13	21,020	18,550	2	2	2	2	4·7	5·4	8 to 8-30 A.M. 6-30 to 6-45 P.M.	8-10 to 8-30 A.M. 6-30 to 6-45 P.M.	
2-9-13	..	..	..	..	..	..	..	..	....	....	Not washed on account of repairs to controller sump.
3-9-13	21,268	16,950	2	2	2	2	4·7	5·9	8-25 to 8-45 A.M. 5 to 5-25 P.M.	8-25 to 8-45 A.M. 5 to 5-25 P.M.	
4-9-13	28,035	14,100	2	2	2	2	3·5	7·1	8 to 8-20 A.M. 5 to 5-20 P.M.	8 to 8-20 A.M. 5 to 5-20 P.M.	
5-9-13	29,645	17,900	2	2	2	2	3·4	5·6	7-45 to 8 A.M. 5-30 to 5-45 P.M.	7-45 to 8 A.M. 5-45 to 6 P.M.	Heavy rain in the night.
6-9-13	27,713	10,550	2	2	2	2	3·6	9·5	7-45 to 8 A.M. 5 to 5-15 P.M.	8 to 8-15 A.M. 5-15 to 5-30 P.M.	
7-9-13	..	..	..	..	..	..	..	..	....	....	Coagulating tanks cleaned.
8-9-13	28,686	..	2	..	2	..	3·4	..	7-30 to 7-45 A.M. 5-15 to 5-30 P.M.	....	
9-9-13	24,169	..	2	..	2	..	4·1	..	8-30 to 8-45 A.M. 5 to 5-15 P.M.	....	
10-9-13	24,190	..	1½	..	2	..	4·1	..	8-30 to 8-45 A.M. 5-15 to 5-30 P.M.	....	
11-9-13	26,768	..	1½	..	2	..	3·7	..	8 to 8-15 A.M. 5-15 to 5-30 P.M.	....	
12-9-13	23,220	..	1½	..	2	..	4·3	..	8 to 8-15 A.M. 5-15 to 5-30 P.M.	....	
13-9-13	19,030	..	1½	..	2	..	5·2	..	8 to 8-15 A.M. 4-15 to 4-30 P.M.	....	
14-9-13	..	..	..	..	..	..	..	..	....	....	Coagulating tanks cleaned out.
15-9-13	..	27,165	..	2	..	2	..	3·6	....	8-15 to 8-30 A.M. 4 to 4-15 P.M.	
16-9-13	..	30,375	..	2	..	2	..	3·2	....	8 to 8-30 A.M. 4-45 to 5 P.M.	
17-9-13	..	33,300	..	2	..	2	..	3·0	....	7 to 7-30 A.M. 5 to 5-30 P.M.	
18-9-13	..	26,900	..	2	..	2	..	3·7	....	8 to 8-30 A.M. 4-45 to 5-15 P.M.	
19-9-13	..	28,050	..	2	..	2	..	3·5	....	7-45 to 8-15 A.M. 4-45 to 5-15 P.M.	
20-9-13	..	26,650	..	2	..	2	..	3·7	....	8 to 8-30 A.M. 5 to 5-15 P.M.	
21-9-13	..	..	..	..	..	..	..	..	....	....	Boiler washed out and coagulating tanks cleaned.

Date.	Quantity of water filtered per 24 hours.		Alumina used, grains per gallon of water.		Number of washes per 24 hours.		Percentage of wash water to filtrate for 24 hours.		Time taken for each wash.		Remarks.
	J.	P.	J.	P.	J.	P.	J.	P.	J.	P.	
22-9-13	25,154	..	1½	..	2	..	3·9	..	8 to 8-15 A.M. 5-15 to 5-45 P.M.	....	
23-9-13	28,380	..	1½	..	2	..	3·5	..	7-30 to 7-45 A.M. 5-45 to 6 P.M.	....	
24-9-13	24,510	..	1½	..	2	..	4·0	..	7-30 to 8 A.M. 6 to 6-15 P.M.	....	
25-9-13	22,250	..	1½	..	2	..	4·4	..	7-30 to 7-45 A.M. 5-30 to 5-45 P.M.	....	
26-9-13	25,150	..	1½	..	2	..	3·9	..	7-30 to 8 A.M. 5-45 to 6 P.M.	....	
27-9-13	24,525	..	1½	..	2	..	4·0	..	8-30 to 8-45 A.M. 6 to 6-15 P.M.	....	
28-9-13	24,525	..	1½	..	2	..	4·0	..	7-30 to 7-45 A.M. 5 to 5-15 P.M.	....	
29-9-13	19,675	..	1½	..	2	..	5·0	..	8-30 to 8-45 A.M. 4-45 to 5-15 P.M.	....	
30-9-13	12,625	..	1½	..	2	..	7·8	..	7-30 to 7-45 A.M. 5 to 5-15 P.M.	....	
1-10-13	21,600	..	2	..	2	..	4·6	..	7 to 7-30 A.M. 5-15 to 5-30 P.M.	....	Stopped at 12, to open and rectify inlet valve.
2-10-13	30,315	..	2½	..	2	..	3·3	..	7 to 7-15 A.M. 5-15 to 5-30 P.M.	....	
3-10-13	23,220	..	2½	..	2	..	4·3	..	7 to 7-15 A.M. 5 to 5-15 P.M.	....	Supply from the storage tank insufficient. Discharge from Jewell filter is calculated at 1,290 gallons per hour.
4-10-13	31,285	..	2½	..	2	..	3·2	..	7 to 7-15 A.M. 5-30 to 5-45 P.M.	....	(According to specification it is 30,925 gals. or 1,289 gals. per hour.)
5-10-13	29,025	..	2½	..	2	..	3·4	..	7-45 to 8 A.M. 5 to 5-15 P.M.	....	
6-10-13	30,115	..	2½	..	2	..	3·3	..	7 to 7-30 A.M 5-30 to 5-45 P.M.	....	According to meter, 800 gals. per hour.
7-10-13	30,312	..	2½	..	2	..	3·2	..	7 to 7-15 A.M. 5 to 5-15 P.M.	....	V. notch gives a reading of $1\frac{13}{16} = 1{\cdot}33$ c.ft. per m. =489 gals. per hour.
8-10-13	30,312	..	2½	..	2	..	3·2	..	7 to 7-15 A.M. 5 to 5-15 P.M.	....	Total .. 1,298.
9-10-13	30,640	..	2½	..	2	..	3·2	..	7 to 7-15 A.M. 5-30 to 5-45 P.M.	....	*Deducting* for eddies, etc., it is taken at 1,290 gals. per hour.
10-10-13	29,992	..	2½	..	2	..	3·3	..	7-15 to 7-30 A.M. 5 to 5-15 P.M.	....	
11-10-13	30,635	..	2½	..	2	..	3·2	..	7 to 7-15 A.M. 5 to 5-30 P.M.	....	
12-10-13	29,337	..	2½	..	2	..	3·4	..	7-30 to 8 A.M. 5-15 to 5-30 P.M.	....	
13-10-13	30,312	..	2½	..	2	..	3·3	..	7 to 7-15 A.M. 5 to 5-15 P.M.	....	
14-10-13	30,312	..	2½	..	2	..	3·3	..	7 to 7-15 A.M. 5 to 5-15 P.M.	....	
15-10-13	24,185	..	2½	..	2	..	4·1	..	7 to 7-15 A.M. 5 to 5-15 P.M.	....	Supply from the storage tank insufficient in the night.
16-10-13	30,312	..	2½	..	2	..	3·3	..	7 to 7-15 A.M. 5 to 5-15 P.M.	....	
17-10-13	30,312	..	2½	..	2	..	3·3	..	Do.	....	
18-10-13	30,312	..	2	..	2	..	3·3	..	Do.	....	
19-10-13	30,312	..	2	..	2	..	3·3	..	Do.	....	
20-10-13	30,312	..	2	..	2	..	3·3	..	Do.	....	
21-10-13	30,312	..	2	..	2	..	3·3	..	Do.	....	
22-10-13	30,312	..	2	..	2	..	3·3	..	Do.	....	
23-10-13	30,312	..	2	..	2	..	3·3	..	Do.	....	
24-10-13	30,312	..	2½	..	2	..	3·3	..	Do.	....	Heavy rain from 2 A.M.
25-10-13	30,312	..	2½	..	2	..	3·3	..	Do.	....	
26-10-13	30,312	..	2½	..	2	..	3·3	..	Do.	....	
27-10-13	30,312	..	2½	..	2	..	3·3	..	Do.	....	
28-10-13	30,312	9,750	2½	2½	2	1	3·3	5·1	Do.	11-45 to 12 noon.	P. tried to-day.
29-10-13	30,310	3,300	2½	2½	2	1	3·3	15·1	7 to 7-15 A.M. 5-30 to 5-45 P.M.	5-45 to 6 P.M.	High floods in the river, and heavy rain.
30-10-13	30,635	16,975	2½	2½	2	1	3·2	2·9	7 to 7-15 A.M. 5 to 5-15 P.M.	5-15 to 5-30 P.M.	P. tried for 3 hours.
31-10-13	16,770	..	2½	..	1	..	3·0	..	7-15 to 7-30 A.M.	....	
1-11-13	..	31,614	..	2½	..	2	..	3·2	....	7-15 to 7-30 A.M. 5-15 to 5-30 P.M.	
2-11-13	..	31,985	..	2½	..	2	..	3·1	....	7 to 7-15 A.M. 5 to 5-15 P.M.	
3-11-13	..	31,180	..	2½	..	2	..	3·2	....	7 to 7-15 A.M. 5-5 to 5-25 P.M.	
4-11-13	..	12,900	..	2½	..	2	..	7·7	....	7-35 to 7-45 A.M. 5 to 5-15 P.M.	

APPENDIX III.

ABSTRACT STATEMENT OF THE RESULTS OF BACTERIOLOGICAL ANALYSES OF WATERS FROM THE GUINDY EXPERIMENTAL FILTERS—MECHANICAL FILTERS.

J. = Jewell. P. = Paterson.

Date of collecting samples.	Description of sample.	Source from which collected.	J.		P.		Remarks.
			Total colonies per c.c. on agar at 37°C.	Fæcal bacilli present in	Total colonies per c.c. on agar at 37°C.	Fæcal bacilli present in	
21-7-13	Storage Tank	Tap in front	900	1 c.c.	900	1 c.c.	and upwards.
Do.	River water	Tap or main	1,200	·1 c.c.	1,200	·1 c.c.	Do.
22-7-13	Storage Tank	6″ below surface	34,700	1 c.c.	34,700	1 c.c.	Do.
	Do.	Tap in front	10,100	1 c.c.	10,100	·1 c.c.	Do.
25-7-13	Do.	Do.	4,830	1 c.c.	4,830	1 c.c.	Do.
30-7-13	Do.	Do.	2,740	1 c.c.	2,740	1 c.c.	Do. Rain on 29-7-13
1-8-13	Do.	Do.	6,390	·1 c.c.	6,390	·1 c.c.	Do. Rain on 31-7-13
5-8-13	Do.	Do.	2,620	..	2,620	..	
8-8-13	Do.	Do.	1,630	..	1,630	..	
15-8-13	Do.	Do.	3,360	·1 c.c.	3,360	·1 c.c.	and upwards.
12-8-13	Do.	Do.	3,660	1 c.c.	3,660	1 c.c.	Do.
19-8-13	Do.	Tap	10,390	·1 c.c.	..	..	
8-9-13	Do.	Do.	39,400	..	..	..	
	Coagulating Tank	..	..	..	..	..	
	C_1 7-40 A.M.	..	750	1 c.c.	..	..	
	C_2 10-10 ,,	..	2,060	·1 c.c.	..	..	
	C^3 4-10 P.M.	..	5,380	·1 c.c.	..	..	
	F^1 7-45 A.M.	..	6,370	·01 c.c.	..	..	
	F^2 8-15 ,,	..	733	1 c.c.	..	..	
	F^3 8-45 ,,	..	320	1 c.c.	..	..	
	F^4 9-15 ,,	..	181	5 c.c.	..	..	
	F^5 10-15 ,,	..	107	5 c.c.	..	..	
	F^6 12-15 P.M.	..	114	1 c.c.	..	..	
	F^7 2-15 ,,	..	119	1 c.c.	..	..	
	F^8 4-15 ,,	..	560	1 c.c.	..	..	
17-9-13	Storage Tank	Tap	3,200	1 c.c.	..	..	
	Coagulating Tank	..	..	..	..	..	
	C_1 7-25 A.M.	..	..	..	1,490	5 c.c.	
	C_2 9-55 ,,	..	..	..	1,000	5 c.c.	
	C^3 3-55 P.M.	..	..	..	3,700	..	
17-9-13	Coagulating Tank	..	..	..	..	..	
	F_1 7-30 A.M.	..	..	..	541	5 c.c.	
	F_2 8 ,,	..	..	..	820	5 c.c.	
	F^3 8-30 ,,	..	..	..	520	5 c.c.	
	F^4 9 ,,	..	..	..	320	30 c.c.	
	F^5 10 ,,	..	..	..	430	20 c.c.	
	F^6 12 Noon	..	..	..	547	1 c.c.	
	F^7 2 P.M.	..	..	..	580	1 c.c.	
	F^8 4 ,,	..	..	..	1,250	5 c.c.	
22-9-13	Storage Tank	Tap	230	5 c.c.	230	5 c.c.	
	Coagulating Tank	Effluent	3,460	1 c.c.	..	..	
	Filtered	10 A.M.	466	5 c.c.	..	..	
24-9-13	Storage Tank	Tap	430	1 c.c.	430	1 c.c.	
	Coagulating Tank	..	1,300	·1 c.c.	..	..	
	Filtered	8·40 A.M.	216	·1 c.c.	..	..	
26-9-13	Storage Tank	Tap	3,300	·1 c.c.	3,300	·1 c.c.	
	Coagulating Tank	Effluent	6,000	·01 c.c.	..	..	
..	Filtered	8·30 A.M.	1,280	1c. c.	..	..	
1-10-13	Storage Tank	Tap	10,600	·01 c.c.	..	..	
	Coagulating Tank	Effluent	2,210	·1 c.c.	..	..	
	Filtered	9 A.M.	102	1 c.c.	..	..	
3-10-13	Storage Tank	Tap	5,700	·01 c.c.	..	..	
	Coagulating Tank	Effluent	2,200	·1 c.c.	..	..	
	Filtered	11 A.M.	81	5 c.c.	..	..	
7-10-13	Storage Tank	Tap	27,500	·01 c.c.	..	..	
	Coagulating Tank	Effluent	1,040	1 c.c.	..	..	
	Filtered	11-5 A.M.	101	5 c.c.	..	..	
10-10-13	Storage Tank	Tap	44,100	·001 c.c.	..	..	River in floods.
	Coagulating Tank	Effluent	1,530	·1 c.c.	..	..	
	Filtered	11-17 A.M.	80	5 c.c.	..	..	
13-10-13	Storage Tank	Tap	21,000	·01 c.c.	..	..	
	Coagulating Tank	Effluent	2,200	1 c.c.	..	..	
	Filtered	..	310	5 c.c.	..	..	
15-10-13	Storage Tank	Tap	4,000	·1 c.c.	..	..	
	Coagulating Tank	Effluent	3,300	·1 c.c.	..	..	
	Filtered	11-7 A.M.	220	1 c.c.	..	..	
17-10-13	Storage Tank	Tap	9,500	·01 c.c.	..	..	
	Coagulating Tank	Effluent	1,590	·1 c.c.	..	..	
	Filtered	11-2 A.M.	186	1 c.c.	..	..	
20-10-13	Storage Tank	Tap	8,800	·01 c.c.	..	..	
	Coagulating Tank	Effluent	4,140	1 c.c.	..	..	
	Filtered	10-56 A.M.	42	·5 c.c.	..	..	
22-10-13	Storage Tank	Tap	17,300	·01 c.c.	..	..	
	Coagulating Tank	Effluent	6,200	·01 c.c.	..	..	
	Filtered	11-13 A.M.	72	·1 c.c.	..	..	

APPENDIX III—*concluded.*

Date of collecting samples.	Description of sample.	Source from which collected.	J.		P.		Remarks.
			Total colonies per c.c. on agar at 37°C.	Fæcal bacilli present in	Total colonies per c.c. on agar at 37°C.	Fæcal bacilli present in	
24–10–13	Storage Tank	Tap	94,000	·01 c.c.	..	..	
	Coagulating Tank	Effluent	84,100	·01 c.c.	..	..	
	Filtered	11-25 A.M.	935	·1 c.c.	..	..	
27–10–13	Storage Tank	Tap	2,20,000	·01 c.c.	..	..	
	Coagulating Tank	Effluent	3,100	·1 c.c.	..	..	
	Filtered	11-47 A.M.	120	5 c.c.	..	..	
29–10–13	Storage Tank	Tap	31,000	·01 c.c.	..	..	
	Coagulating Tank	Effluent	7,800	·1 c.c.	..	..	
	Filtered	8-15 A.M.	220	1 c.c.	..	..	
31–10–13	Storage Tank	Tap	25,000	·01 c.c.	..	..	
	Coagulating Tank	Effluent	1,390	·1 c.c.	..	..	
	Filtered	11-35 A.M.	12	20 c.c.	..	..	
3–11–13	Storage Tank	Tap	..	..	Countless (13,200)	·01 c.c.	
	Coagulating Tank	Effluent	..	..	5,900	·1 c.c.	
	Filtered	..	..	..	1,900	1 c.c.	
5–11–13	Storage Tank	Tap	..	..	5,900	·1 c.c.	
	Coagulating Tank	Effluent	..	..	4,900	1 c.c.	
	Filtered	..	..	..	520	1 c.c.	
–11–13	Storage Tank	Tap	..	..	3,000	·1 c.c.	
	Coagulating Tank	Effluent	..	..	700	1 c.c.	
	Filtered	..	..	..	130	5 c.c.	
10–11–13	Storage Tank	Tap	..	..	Countless (42,000	·01 c.c.	
	Coagulating Tank	Effluent	..	..	9,200)	·1 c.c.	
	Filtered	..	..	..	1,060	1 c.c.	

APPENDIX IV.

GUINDY EXPERIMENTAL FILTERS—ABSTRACT STATEMENT OF BACTERIOLOGICAL RESULTS OF WATER FROM SAND FILTER.

C. = Clemesha Filter. M. = Madras Standard Filter.

Date of collecting samples.	Description of sample.	Source from which collected.	C.		M.		Remarks.
		C. M.	Total colonies per c.c. on agar at 37°C.	Fæcal bacilli present in	Total colonies per c.c. on agar at 37°C.	Fæcal bacilli present in	
5-8-13	Unfiltered	1st Tap	1,360	1 c.c.	..	..	
	Filtered	2nd ,,	87	60 c.c.	..	..	
	Do.	3rd ,,	60	60 c.c.	..	..	
	Do.	4th ,,	48	..	..	..	
	Do.	5th ,,	51	20 c.c.	..	..	
	Do.	6th ,,	70	20 c.c.	..	..	
	Do.	Outlet	100	60 c.c.	..	..	
8-8-13	Unfiltered	1st Tap	..	..	1,750	1 c.c.	
	Do.	2nd ,,	..	..	1,600	·1 c.c.	
	Filtered	3rd ,,	..	..	229	5 c.c.	
	Do.	4th ,,	..	..	66	60 c.c.	
	Do.	5th ,,	..	..	50	60 c.c.	Not present in.
	Do.	Outlet	..	..	75	60 c.c.	Do.
12-8-13	Unfiltered	1st Tap	1,700	·1 c.c.	..	..	
	Filtered	2nd ,,	590	10 c.c.	..	..	
	Do.	3rd ,,	105	10 c.c.	..	..	
	Do.	4th ,,	68	20 c.c.	..	..	
	Do.	5th ,,	73	10 c.c.	..	..	
	Do.	6th ,,	77	60 c.c.	..	..	Not present in.
	Do.	Outlet	99	20 c.c.	..	..	
15-8-13	Unfiltered	1st Tap	..	..	1,750	1 c.c.	
	Do.	2nd ,,	..	..	2,050	1 c.c.	
	Filtered	3rd ,,	..	..	373	5 c.c.	
	Do.	4th ,,	..	..	194	1 c.c.	
	Do.	5th ,,	..	..	91	5 c.c.	
	Do.	Outlet	..	..	63	30 c.c.	
19-8-13	Unfiltered	1st Tap	14,400	·1 c.c.	..	..	
	Filtered	2nd ,,	6,280	1 c.c.	..	..	
	Do.	3rd ,,	7,550	1 c.c.	..	..	
	Do.	4th ,,	6,640	1 c.c.	..	..	
	Do.	5th ,,	8,180	1 c.c.	..	..	
	Do.	6th ,,	4,610	·1 c.c.	..	..	
	Do.	Outlet	5,290	1 c.c.	..	..	
22-9-13	Do.	Do.	32	20 c.c.	105	5 c.c.	
24-9-13	Do.	Do.	22	..	..	..	
26-9-13	Do.	Do.	Cannot be counted	5 c.c.	2,330	1 c.c.	
1-10-13	Do.	Do.	210	1 c.c.	75	60 c.c.	Not present in.
3-10-13	Do.	Do.	314	1 c.c.	Cannot be counted	30 c.c.	
7-10-13	Do.	Do.	Cannot be counted (2 big and 265 small colonies.)	1 c.c.	340	5 c.c.	
10-10-13	Do.	Do.	970	·1 c.c.	630	1 c.c.	
13-10-13	Do.	Do.	1,940	1 c.c.	1 big & 527 small colonies.	1 c.c.	
15-10-13	Do.	Do.	850	5 c.c.	580	5 c.c.	
17-10-13	Do.	Do.	290	5 c.c.	340	20 c.c.	
20-10-13	Do.	Do.	190	10 c.c.	108	20 c.c.	
22-10-13	Do.	Do.	185	10 c.c.	..	..	
24-10-13	Do.	Do.	265	5 c.c.	895	1 c.c.	
27-10-13	Do.	Do.	4,300	1 c.c.	1,200	1 c.c.	
29-10-13	Do.	Do.	3,700	1 c.c.	1,610	1 c.c.	River in floods.
31-10-13	Do.	Do.	Cannot be counted	1 c.c.	3,200	1 c.c.	Ditto.
3-11-13	Do.	Do.	870	5 c.c.	840	5 c.c.	
5-11-13	Do.	Do.	500	10 c.c.	267	20 c.c.	
7-11-13	Do.	Do.	270	5 c.c.	..	..	
10-11-13	Do.	Do.	810	1 c.c.	830	1 c.c.	

NOTE ON THE WORKING OF THE CO-OPERATIVE DAIRY SOCIETY AT LUCKNOW.

BY

MAJOR S. A. HARRIS, I.M.S.,

Sanitary Commissioner, United Provinces.

HISTORY OF GHOSIS' CO-OPERATIVE SOCIETY.

THE Ghosi Co-operative Society at the Diamond Dairy, Husainganj, Lucknow, has been in existence for the past 2½ years as a cash credit society. The society supplied milk to the proprietor of the Diamond Dairy, who paid the Ghosis at the rate of 11 seers per rupee and sold the milk to customers at 7 and 8 seers per rupee.

In former days funds for the founding of the Co-operative societies were borrowed at 7 to 9 per cent. from any capitalist who was willing to advance the money. In July 1913 a Central Co-operative Bank, Limited, was established which receives deposits from the public at 6 and 7 per cent. and borrows from the Allahabad Bank at 7 per cent.

This Central Co-operative Bank gives advances to registered societies at 13-8 per cent. per annum, from which, together with the shares paid by the members, the registered society is able to advance money on loan to its members, at 15 per cent. per annum.

FORMATION OF THE SOCIETY.

For the formation of a society to work on Co-operative lines ten or more persons must submit an application to the Registrar of Co-operative Societies for permission to form a Society, Limited or Unlimited. The Registrar makes enquiries as to the status of the application, and satisfies himself that the persons wishing to form a co-operative society are engaged in business, are honest men and not heavily indebted to mahajans. The society is then registered and money is advanced by the bank for the needs of its members on joint responsibility. In each society there is a working committee which consists of certain elected members from among the shareholders.

There is also a paid Secretary who serves a group of 10 to 12 societies.

Co-operative societies are divided into two classes, *viz.*, agriculture and non-agriculture. In the latter, for each Rs. 50 advance given, one share must be taken.

Any member wishing to join a society has to take at least one Rs. 20 share which is payable in 10 years by 20 half-yearly instalments. In the interim, until the share is fully paid up, the member receives no profit or dividends. The money which is paid for shares is put into the capital which, as above stated, is utilized in giving advances to members. The object on which the money is to be spent must be stated, and after the advance has been taken enquiry is made by the society if the sum is utilized for the purpose for which it was borrowed.

The members of the society hold a Committee meeting and if they are not satisfied with the methods in which the money advanced to a member has been spent, repayment is insisted on or, as a last resource, a civil suit is instituted for the recovery of the money.

To enable the society to be run on business and sanitary lines an Inspector of Co-operative societies, M. Usuf Ali in charge of Lucknow circle, has been appointed, who supervises the business and pays occasional inspections to see that the Ghosis keep the *byres* clean, that the fodder of the animals is of good quality and that the milking is properly conducted, in the presence of the paid staff of the dairy.

The Lucknow Ghosi Co-operative Dairy has the following non-official members:—

Deputy Commissioner as Chairman.

Mr. A. P. Sen, Barrister-at-law.

Mr. Azhar Ali, B.A., pleader and Honorary Manager of the Co-operative Central Bank, Limited, who has also a paid manager with duties to reside in the Dairy and supervise all its arrangements.

The punishments for adulteration are as follows :—

Any *gwala* found diluting the milk with water or in any other way adulterating it will be fined Rs. 10 for the first offence and Rs. 50 for the second, and suffers expulsion on detection in a third offence. Butter, cream and ghee are made on the premises.

A pasteurization plant will be introduced as soon as the funds of the Society permit.

The Lucknow Co-operative Dairy from the advance of Rs. 6,000 lent by the Municipal Board have erected a *byre* in which all the animals are tied facing outwards to obviate as far as possible risk of infection. Their feeding-troughs are outside the *byre* in the open.

Dry cattle are sent to the Bahraich District where the Society has bought grazing rights.

The bye-laws of the Lucknow Co-operative Dairy, unlimited with reference to membership, administration, meeting of the Committee, methods of business, &c., are as follows :—

Bye-laws of the Co-operative Dairy, Limited, Lucknow.

The Society shall be called fforde's Co-operative Dairy Lucknow and its registered address shall be at Mohalla Baraf Khana, Tahsil and District Lucknow.

2. The objects of the Society shall be :—

(1) To supply milk and other dairy produce to consumers.
(2) To sell the dairy produce of the members on a co-operative basis.
(3) To provide its members with loans for necessary objects and particularly for the purchase of milch-cattle and fodder at a moderate rate of interest and to encourage among them thrift, self-help, and co-operation.

3. Its capital shall consist of an undetermined number of shares of Rs. 20 each and of profits, loans and deposits. The Society shall be entitled to acquire shares in the Central Bank, Lucknow.

4. The operations of the Society shall be confined to the District of Lucknow.

Membership.

5. Any person of good character and sound mind and above the age of 18 who owns milch-cattle and carries on business in the sale of milk and dairy produce in the town of Lucknow shall be eligible as a member.

6. The original members shall be those who sign the application for registration. Subsequent members shall be elected by a three-fourth majority at a general meeting.

7. All members are jointly and severally liable to the extent of their whole property for the debts of the Society.

8. Every member shall take at least one share and as many extra shares as shall be fixed by the working Committee in consideration of his status, but no member shall take more than 50 shares ; payment towards each share shall be made in 20 half-yearly instalments of Re. 1.

9. Every member shall begin from the first to pay his instalments towards the number of shares fixed for him by the Working Committee under the above rule, but he may at any time purchase and commence payment of instalments towards more shares.

10. Instalments shall be regularly paid on the dates fixed by the Working Committee, extension of time being allowed only in individual cases and for sufficient reasons. A fine not exceeding three pies in the rupee may be charged on every overdue instalment.

11. A member shall not transfer any share held by him unless :—

(*a*) he has held such share for not less than one year; and (*b*) the transfer is made to a member approved for that purpose by the Working Committee.

12. Every member shall keep all his milch-cattle in the Dairy premises and shall also live there himself if directed by the Committee to do so. The Committee shall have power to permit a member to keep cattle outside the Dairy premises, at an authorised place.

13. Every member shall deliver daily to the society all the milk produced by his cattle at a rate or rates that will be fixed by the Committee.

14. A member may, provided he is not in debt to his Society or is not surety for an unpaid debt, withdraw from the Society after giving one month's notice to the Secretary.

15. A member who ceases to be qualified under the bye-laws may be removed by the Committee.

16. A member may be expelled by a resolution passed at a general meeting by a two-thirds majority of those present at the meeting. He shall only be expelled for failure to pay due debts and share instalments, or for dishonest dealing with the Society, or attempts to injure it, or for other grave misconduct.

17. A member withdrawing, removed, or expelled from the Society shall be entitled after two years from the date of his ceasing to be a member to repayment, without interest, of any money paid by him towards the purchase of a share or shares.

ADMINISTRATION.

18. The Dairy shall be managed by a Committee of seven members, four of whom will be elected from among the members themselves, and three, including the chairman, will be nominated by the Lucknow Central Banking Union.

The members of the Committee shall be elected by the shareholders every year. A retiring member shall be eligible for re-election.

Members of the Committee may be removed at any time by the shareholders for incompetency, negligence or other grave misconduct.

Vacancies occurring within the year may be filled up by the members of the Committee.

19. The Committee shall have the following powers :—

(1) To elect a Vice-Chairman.
(2) To appoint, dismiss, remove, suspend or otherwise punish any salaried or non-salaried officer or employé of the Dairy, and to require all or any of them to furnish sufficient security.
(3) To contract loans, or otherwise raise capital on behalf of the Dairy not in excess of the amount fixed as the maximum liability for the year by the shareholders in the annual general meeting, and to pledge the Society's credit for such loans.
(4) To arrange for the meeting required to be held under bye-laws and to submit to them the annual or half-yearly reports and balance sheet of the Society, and such other statements as may be required by the shareholders or the Registrar of Co-operative Societies, United Provinces.
(5) To publish the annual balance sheet of the Society.
(6) Through any of their members or the Manager to institute, conduct, defend, compromise, refer to arbitration, or abandon legal proceedings and claims by or against the Society or Committee or other officers concerning the affairs of the Society.
(7) To fix the rate of interest on loans, deposits, and other borrowings.
(8) To appoint an auditor and legal advisor of the Society.
(9) To admit new shareholders and to allot shares in the Society.
(10) To fix annually the maximum amount of the credit for each shareholder.
(11) To consider and pass orders in case of overdue or misapplied loans and take any necessary and lawful action for their recovery.
(12) To examine and check the accounts of the society and to prescribe, with the previous approval of the Registrar, the forms to be used in accounts and registers and other books and documents of the Society.
(13) To sanction contingent expenditure incurred by the Manager.
(14) To regulate the routine of the office.
(15) To make arrangements for the proper control, inspection and audit of the accounts and working of the dairy.
(16) To arrange for the receipt, disbursal and safe custody of money and other property of the Society.
(17) To sign all papers and instruments executed by or on behalf of the Society.
(18) To acquire shares on behalf of the society in the Lucknow Central Bank.
(19) To consider inspection and audit notes of the Registrar and his assistants and, if necessary, to submit proposals thereon to a general meeting of the Society.
(20) To fix the rate or rates that will be allowed by the Society to its members for their milk.
(21) To make suitable arrangements for the manufacture of dairy produce, such as butter, cream, ghi, etc.
(22) To make suitable arrangements for the sale of milk and dairy produce.
(23) To arrange for the co-operative purchase of fodder and other dairy requisites and, where the fodder is supplied by the members, to arrange for its inspection.
(24) To recommend the expulsion of a member as provided by Bye-law 14.
(25) To accept the resignation of a member.
(26) To hear and decide complaints relating to the business of the Society.
(27) To deal with applications for loans, and to accept or reject sureties for loans.

(28) To supervise the punctual repayment of loans and share instalments and to make proper arrangements for their recovery.

(29) To see that loans are applied to the purpose for which they were granted.

(30) To fix dates for the payment of instalments towards shares and for the repayment of loans.

(31) To levy a charge on overdue loans and instalments towards shares.

(32) To extend the time for payment of instalments towards shares and for repayment of loans in accordance with Bye-laws 3 and 38, subject to the confirmation of the general meeting.

(33) To make proposals to the general meeting for payment of dividends and disposal of profits and reserve in accordance with the rules and bye-laws.

(34) To receive applications for membership and to decide the number of shares which each member shall acquire in the Society.

(35) Generally to conduct the business of the Society and to frame rules for that purpose, in accordance with these bye-laws and the provisions of that Act and Rules made thereunder.

20. The Committee may appoint from among themselves, or from outside, a salaried or honorary manager, to carry on under their supervision the business of the Society.

21. The Committee may appoint from among themselves a Working Committee of three, and make over to it all or any of the duties assigned to them.

22. The Manager, if appointed, shall have the following powers and duties. He shall reside in the premises of the dairy :—

(*a*) To superintend the work of the office and be responsible for the efficient keeping of accounts.

(*b*) To keep accurately and up to date all accounts and books required by the rules and bye-laws, to prepare all receipts, vouchers and other documents required for the transaction of the business of the Society, to conduct correspondence and to supply all necessary information.

(*c*) To get the animals milked in his presence, to inspect their fodder, and to see that all rules of sanitation are strictly observed.

(*d*) To receive and disburse money of the Society in accordance with the rules, if any, made under these bye-laws.

(*e*) To incur expenditure on contingencies within the limits fixed by the Committee.

(*f*) To sign on behalf of the Society all receipts (for less than Rs. 100) and papers to which the Society is a party, all other charges or instruments executed by or on behalf of the Society being signed by at least one member of Committee in addition to the Manager.

(*g*) To conduct all correspondence on behalf of the Society.

(*h*) To summon and attend all general meetings, and meetings of the Committee, and to record their proceedings.

(*i*) To prepare for submission to the Committee the annual statement, reports and balance sheet, and to submit at any time such other statements or reports as the Registrar or the Committee may order.

(*j*) Generally to conduct current business of the Society, and to perform any duties entrusted to him by the Committee.

MEETINGS OF COMMITTEE, WORKING COMMITTEE AND GENERAL MEETINGS.

23. The Committee shall meet as often as the business of the Society may require and in any case at intervals of not more than one month. A Special Meeting shall be held at any time on the requisition in writing of two members or on the order of the chairman.

24. Two members of the Committee, including the Chairman, shall form a quorum for a meeting of the Committee.

25. In all meetings of the Committee every member shall have one vote, the chairman having a casting vote in case of equality of votes. In the absence of the chairman and vice-chairman, the members shall elect one of their number, chairman for the meeting.

26. The proceedings of all meetings shall be recorded in a minute book kept by the manager and shall be signed by the chairman of the meeting in token of correctness.

27. A general meeting of shareholders shall be held :—

(*a*) In July of each year. This shall be called the Annual General Meeting.

(*b*) Whenever summoned by the Chairman or a majority of the Committee or at the written request of 10 shareholders.

28. In the absence of the chairman or vice-chairman, the shareholders present shall elect one of their number chairman for the meeting.

29. At least one week's notice shall be given to all shareholders before a general meeting shall be held.

30. One-fourth of the shareholders shall form a quorum. At an adjourned general meeting one-sixth shall be sufficient for a quorum.

31. Each shareholder shall have one vote and shall only be entitled to vote when present.

32. All questions submitted for decisions shall be decided by a majority of votes unless otherwise especially directed by the bye-laws.

33. In the Annual General Meeting the Committee shall submit to the shareholders the report, accounts and balance sheet of the Society for the year ending on the previous 30th June.

34. The shareholders shall in the Annual General Meeting :—

(1) Elect four members of the Committee for the year.
(2) Consider the annual report, statements and balance sheets and, if profits admit, declare a dividend, and direct the disposal of profits in accordance with the Act, rules, and any general order issued which applies to the Society.
(3) Fix the maximum amount of liabilities to be incurred by the Society during the year.
(4) Fix the maximum credit of each member on the report of the Working Committee.
(5) Fix the maximum amount of loan that may be given to any individual member during the year.
(6) Consider the proposals of the Working Committee on the inspection and audit notes of the Registrar and his staff and of the officers of the Central Society to which the Society is affiliated.
(7) Fill up casual vacancies in the Working Committee.
(8) Consider proposals for the removal of any member of the Committee.
(9) Consider proposals for the removal or expulsion of any member.
(10) Transact any other business that may be laid before it.

Methods of Business.

35. Loans may be granted to a member for any necessary purpose, but preference shall be given to loans for purchase of milch-cattle and fodder.

36. The acknowledgment of a loan by the borrower shall be in the form of a pro. note or in any other manner that may be prescribed by the Committee for that particular case.

37. Two sureties shall be required for all loans.

38. Sureties shall always be persons approved by a Working Committee. If a surety ceases to act as such by death or otherwise, the borrower shall at once either provide another surety or refund the loan. Sureties are responsible that a loan is applied to the purpose for which it is taken and that the borrower does not abscond to avoid payment. In case a loan is misapplied, or the borrower makes preparations to abscond, it is the duty of the sureties to inform the Working Committee.

39. Applicants for loans shall state truly and clearly the purpose for which the loan is required and shall make their applications at meetings of their Working Committee, either verbally or in writing, and the Working Committee after considering the application, shall grant a loan of such an amount within the maximum normal credit fixed for the borrower and on such terms as they think fit, in accordance with these bye-laws or they may refuse to make a loan.

40. Loans shall always be granted with a specific object and applied to that object. If the loan is not applied to the object for which it is granted, it may be recalled at any time by order of the Working Committee.

41. Dates of repayment shall be fixed at the time of the grant with reference to the object of the loans and the ability of the grantee to make such repayment. In particular, in the case of loans for the cultivation of a crop, such dates shall be fixed with reference to the harvesting and sale of that crop, and in the case of loans for trade and manufacture, with reference to the time or season at which the profits of such trade or manufacture are ordinarily realised.

42. The rate of interest on all loans shall be for the present 15 per cent. per annum. Small loans on the Ughai system shall be repayable by twelve monthly instalments of Re. 1 for every Rs. 11 advanced.

43. The Working Committee shall decide whether a loan shall be repayable by instalments. When the rate of interest in Rs. 15 per cent. per annum all loans shall be advanced in multiples of five. For purposes of calculating interest, 4 days or more shall be considered as one week and three days or less shall be ignored.

44. All loans with interest shall be repaid punctually on or before the dates fixed by the Working Committee for repayment. When a payment is made it shall be applied, first, to any interest due up to the date of payment, and, secondly, to reduction of principal.

45. Extension of time shall only be allowed by the Working Committee in exceptional cases. Such extension will not be held to place the amount in arrears.

46. Additional interest, not exceeding three pies in the rupee per mensem, shall be charged on all overdue loans, unless the Working Committee has granted an extension, or the defaulter satisfies the Working Committee that his failure to pay has been due to causes beyond his control.

47. The Society may receive fixed deposits from all members and from any other person who may be approved by the Working Committee on the following terms with regard to interest and repayment ; provided that it shall not be bound to pay any principal or interest to the depositor except during the months of January and July.

Repayable at 6 months' notice 9 per cent. = 12 annas per month.
" " 3 " " 7½ " = 10 " "

48. The cattle will be milked every day in the presence of the manager or his assistants.

49. If any milk dealer be found diluting the milk with water, or in any other way adulterating it, he will be fined Rs. 10 for the first offence, Rs. 50 for the second offence, and will be expelled from the Society for the third offence.

50. The rate that will be allowed to members for milk and dairy produce will be fixed by the Committee from time to time.

51. The disposal of the produce of the dairy will be entirely in the hands of the Committee.

Profits.

52. All net profits shall be credited at first to the Reserve Fund. After ten years from the date of registration of the Society they shall be disposed of as follows :—

1st. One-fourth shall go to the reserve fund.

2nd. Out of the remainder one-tenth may be applied, with the sanction of the Registrar, to a charitable purpose.

3rd. The remainder shall be applied to the payment of a dividend, not exceeding ten per cent. on all shares fully paid up, provided that ten years have elapsed from the date of payment of the first instalment in respect of such share.

53. The reserve fund shall be invested or deposited in one or more of the modes mentioned in section 32, sub-section (1), clauses (*a*), (*b*), (*c*) and (*d*) of Act II of 1912.

54. The reserve fund shall be indivisible and no member shall have any claim to a specified share in it.

55. (1) On the dissolution of the society the reserve fund shall be applied first to discharging the liabilities of the society and to the repayment of the share capital paid up, and if for any period no dividend has been paid from profits, to the payment of a dividend for such period at a rate not exceeding 7 per cent. per annum.

(2) Such portion of the reserve fund as shall remain after the repayments mentioned in sub-clause (1) shall be applied to such local object of public utility as may be selected by the Committee and approved by the Registrar. If within three months of the dissolution of the Society the Committee fails to make any selection that is approved by the Registrar, the latter shall place the amount on deposit in some co-operative or other bank until a new Co-operative Society within the district of its area operations is registered, in which event it shall be credited to the reserve fund of such Society.

56. All disputes between the society and its shareholders concerning the business or working of the Society shall be decided by the Committee, subject to an appeal to a general meeting, whose decision shall be final and not removeable to any Court of Law.

57. The Society shall be liquidated only with the sanction of two-thirds of the shareholders assembled in a General Meeting, called especially to consider the question and with the sanction of the Registrar.

58. No alteration or addition shall be made to these bye-laws except by a two-thirds majority of shareholders, at a special meeting called for the purpose. A quorum of one-third of the total number of members shall be required at such a meeting.

NOTE ON THE INSTITUTION AND MANAGEMENT OF CO-OPERATIVE DAIRIES IN THE UNITED PROVINCES, WITH SPECIAL REFERENCE TO THE CO-OPERATIVE DAIRIES IN EXISTENCE AT BENARES AND LUCKNOW.

BY

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Co-operative dairies are at present working in the cities of Benares, Allahabad, Lucknow and Gorakhpur. The Benares dairy was registered in June 1911. The Allahabad dairy started work last July, the Lucknow Dairy last December and the Gorakhpur dairy starts this month. These dairies are all the enterprises of milk producers which have been organised in villages where credit associations already exist, and the producing and selling association which constitutes the dairy is always combined with a credit association which advances loans for the purchase of milch-cattle, for the erection of sheds, for fodder, for housing and for the purchase of plant. The credit association is financed by the central or district bank but in some cases where the initial capital required exceeds the amount which the central institution is prepared, in the normal course of co-operative business, to advance, the credit branch of the dairy society has, as at Lucknow, received a special loan from the Municipality.

2. The formation of these dairy societies follows the ordinary lines on which co-operative credit societies come into being. One of the Registrar's inspectors, often aided by some public-spirited gentlemen interested in the project, explains to a group of Ahirs or Ghosis who are members of a progressive society working in some village or villages near the city, and already acquainted with the principles and benefits of co-operation, the profits and advantages of extending their present combination for credit (whereby they are enable to purchase milch-cattle) by an association for selling their milk and manufacturing and marketing other dairy produce in the city. When a sufficient nucleus willing to embark on the enterprise has been obtained, a society is organised after discussion with the members and with gentlemen in the city who may associate themselves with the project, either by taking shares or as helpers and advisers, and bye-laws are framed by the Registrar and registered, the applicants for registration forming the original society. New members enter the society by election at a general meeting. The society is organised on a share basis. Where the dairy society is composed entirely of milk-sellers the liability is preferably unlimited. Where, as sometimes happens, substantial residents of the city are anxious to associate themselves with the enterprise as shareholders, liability is sometimes limited to the normal value of the shares. In such cases only a portion ($\frac{1}{2}$ or $\frac{1}{4}$) of the share is paid up, the remainder constituting reserve liability only subject to call in event of liquidation. In Benares and Gorakhpur liability has been limited, in Allahabad and Lucknow liability is unlimited, the reason for the distinction being that in the latter the dairies are entirely the *gwalas'* own enterprise, and managed wholly by the milk-sellers themselves, whereas in the former public-spirited citizens have taken shares in the business and accordingly bear a part in its management. After registration and the formation of the *panchayat* or managing committee the next step is to advance loans for the purchase of cattle, since all the members have usually not enough cattle to maintain a regular supply of milk. In order to enable the committee and the financing institution to ascertain to what extent such loans are necessary, safe and justifiable, a kind of census of each member's cattle and general credit is undertaken and a register called the status or *haisiyat* register prepared. Loans are then advanced. Foresight is necessary to ensure a steady supply of milk. In some of the earlier experiments it was not adequately recognized that even co-operative cows run dry. Unless a fairly constant supply is maintained the regular customer is disgusted, the market upset and it is impossible to adjust to the business a regular ratio of working expenses.

3. The loans are granted by the committee of the society (though at the earliest stages their issue is carefully watched and regulated by the department). The joint and several liability of its members is relied on to ensure that loans are not granted beyond such as are necessary and promise profit and that they are expended on the purchase of cattle. It is to each member's interest to see that his fellow member plays fair in these matters. Each member is required to have his milch-cattle milked at one place and one time. A price is fixed by the society which is paid weekly to the members for the milk furnished by them—usually 10 or 11 seers a rupee. The milk is sold to the public at 8 or 7 seers a rupee and the manufactured products of the milk at prices depending on the local markets. The margin between the prices paid to members and charged to the public constitutes the profits, which, after deduction of working expenses and interest on loans, return to the members in two capacities (1) as shareholders, (2) as milk suppliers. Profits are disposed of as follows :—

In dairy societies with unlimited liability—

1*st*—One-fourth goes to reserve fund.

2*nd*—A bonus not exceeding a limited percentage of profits is distributed to suppliers of milk and other dairy produce in proportion to the value of their supplies.

3*rd*—A dividend not exceeding ten per cent. may be paid on all fully paid up shares *after ten years have elapsed* since the formation of the society.

4*th*—The balance if any goes to the reserve fund.

It will be seen that the chief object kept in view is the early accumulation of a substantial reserve fund which will improve the credit of the society and enable it to finance its members more cheaply and to pay off the initial borrowed capital.

In the case of societies with limited liability, profits are distributed as follows :—

1*st*—One-fourth to reserve fund.

2*nd*—A dividend limited to 7 per cent. on all shares fully paid up.

3*rd*—A sum not exceeding 20 per cent. of profits (in Benares *all* profits remaining) to be distributed among members in proportion to the value of milk and other produce supplied.

4*th*—Balance to reserve fund.

There are also provisions for distribution to charity.

4. So far, the development of dairy societies may be treated as proceeding on identical lines, but at this point divergence in local conditions necessitates separate treatment. It will be desirable to briefly indicate the features which differentiate the four important dairies.

5. In Benares the organisation consists of two separate farms situated in villages five or six miles distant from Benares city. At these farms sheds have been erected at which the members have to keep their cattle—the cattle are fed and milked under supervision, the milk is collected and locked by the manager in cans so contrived that while milk can be poured out nothing can be poured in. The cans are carried by *ekka* to five shops in the city where the milk is sold for cash and on the coupon system. The Ahirs are paid for their milk at 10 seers and it is sold at the shops at 8. The demand exceeds the supply and the scene at the shop resembles the third-class booking office of a large railway station. Commercially the enterprise has not so far proved a great success, though it has paid its way. Conditions in Benares are peculiarly adverse. Owing to the congested character of the city area it has been impossible to establish milking depôts nearer than the present farms, and the cardinal difficulty has accordingly been that of transport which eats up most of the profit. There has also been internal trouble in one of the villages which resulted in the closing of the farm and its replacement by another which is so far working satisfactorily. The margin between price paid and price charged appears to have been fixed too low, though at the present stage it seems impossible either to get the Ahirs to agree to a lower purchase rate or the citizens of Benares to pay more for pure milk than they are used to pay for the diluted and adulterated liquid hitherto available to them. Were it possible to tap by cheap motor transport villages a little further out from the city, there are existing societies which could be organised without difficulty so as to double or treble the milk supply. The working of societies in these villages would probably be free from many of the difficulties which have to be surmounted in villages close to Benares city. The dairy society has lent large sums to its members and is not in a position to embark on the heavy initial expenditure involved in the establishment of motor transport. It may be justifiable to invoke Government or Municipal aid to that end, though the acceptance of such assistance save on strictly commercial terms is strongly repugnant to orthodox co-operative principles.

6. The conditions at Lucknow are widely different to those obtaining at Benares. In this city of wider spaces, owing to the kindness of the authorities and

in particular to the constant and practical sympathy of the Deputy Commissioner, Mr. fforde, it has been possible to find a spacious and unenclosed site close to the large hotels and to Hazaratganj. Thanks to a loan of Rs. 6,000 received from the Municipality, the Ghosi members of the society have built a large cattle shed, quarters for their own habitation, a dairy building with separator and churn, and other necessary buildings. Good drainage has been arranged and there will be a water-flush latrine. Cattle (which are mainly buffaloes) are kept at the shed and milking and feeding are under supervision. The Ghosis are paid at 11 seers a rupee and the milk is sold at 8 seers. Much of the milk produced is at present converted into butter. The dairy has only been working for a month. So far it is aiming at supplying the larger institutions and wealthier inhabitants. It has already succeeded in placing most of its outturn. It does not so far sell at any shop or attempt to cater for the bazar demand. This development will probably take place later when the Municipality have given effect to their proposals to regulate the sale of milk. The dairy undertakes house-to-house distribution itself, and save by the sale of coupon books does not sell for cash. It has started well, having made a profit of Rs. 180 on the first month's working, but it is early to form any opinion as to its ultimate success, which must depend on the co-operative intelligence and integrity of its members.

7. The Allahabad dairy society is of a more elementary type. The Ahirs of Beli, a village very close to the Katra bazar, have been organised. They keep their cattle in their own village, but bring them (when in milk) to a large compound in Katra to be milked under the supervision of a manager, and the milk is taken in locked cans to a shop in the adjoining Katra bazar and there sold to the public. Price to the Ahirs is 10 seers and to the public 7 seers. No attempt has as yet been made to sell in the city. Power has been taken in the bye-laws in order that members may eventually be compelled to build sheds at which cattle in milk must be kept, and for inspection of cattle, their housing and feeding, for exclusion of cattle that are sick or kept in insanitary surroundings and for notification of disease. The dairy is so far doing well.

8. The Gorakhpur dairy will be of the Benares type, but the transport problem does not promise to be so acute. A fine open site has been selected about two miles from the city. There a large *pukka* shed will be built and milk will be sent into the town every morning and sold at two shops in the city. Two or three of the leading Ahirs were sent to Benares to be shown the working of the society there and returned much inspirited; they are ready to pay up substantial shares in the first year and to forego distribution of profits till they have built up a solid reserve.

9. One more dairy deserves mention as unique of its type. In Basti some of the wealthier inhabitants, who have found it difficult to obtain milk of a satisfactory quality, have established a *consumers'* dairy. They have engaged a manager and two *gwalas*, purchased about a dozen cattle (of the Ballia breed) and lease on favourable terms some good grazing on the parade ground. Milk is sold to members at market price, and profits will go to consumers in proportion to their consumption after a fair dividend has been paid on shares. The dairy is now flourishing. It will, however, require very careful supervision since the interests of the consumer and his agents who milk and feed the cattle are divergent and not identical as in producers' dairies.

10. As regards the feeding of milch-cattle, experience goes to show that the *gwala* may himself be trusted to obtain the maximum of milk from the minimum of diet, and to feed his cattle generously if he can afford it. It is directly to his interest to do so and moreover any method of feeding which would depreciate the common output of milk would be strongly discouraged by his fellow members.

Where, however, as in almost all dairies, milch-cattle have to be kept at the shed, both the staff and the committee itself are in a position to supervise the feeding, and do so. Where societies have as in Lucknow built sheds within municipal limits, they have as yet shown no disinclination to accept all practicable sanitary requirements on the part of the municipal authorities. I have in fact both in the matter of cleanliness and of adulteration been surprised at the appreciation shown by the societies of the fact that dirt and adulteration are bad business. The Allahabad society expelled the other day a man detected adding water to his milk and readily showed Mr. Hamilton the common trade methods of adulterating milk.

11. Co-operation applies very powerful stimuli to the maintenance of a decent standard of cleanliness of cattle-keeping and purity of milk and in any case it is clear that no other agency save that of the dairy men themselves can effectively secure it, for it is impossible for the departmental staff to supervise operations save in the infancy of a society. Where societies have their sheds within municipal limits constant inspection by the municipal health officer will be welcomed and will help to enforce the standard observed. From the bye-laws it will be observed that power has been taken to enforce sanitary requirements, *e.g.*, that milch-cattle

are kept under clean and sanitary conditions, that milk be tested, pasteurized or otherwise sterilized, and for the enforced segregation of diseased cattle.

12. I have recently been examining in the light of Mr. Hailey's note on the improvement of the milk supply in the towns of the United Provinces, the points in which co-operative dairies might justifiably look to the municipalities for help in the early stages of their enterprise—which, while primarily directed towards the improvement of their members' position and the emancipation of their industry, would incidentally seem the most promising avenue towards the improvement desiderated.

The points would seem to be (1) help in the heavy initial expenditure required for the provision of quick transport—preferably motor transport. As already pointed out, this is in Benares the key to an effective milk service and its absence appears to block all progress. Further developments in Allahabad will probably have to face the same obstacle.

(2) The provision of fodder. As Mr. Hailey has shown, the solution is rather to be sought in the growing of fodder crops than in making grazing areas available. With the development of agricultural co-operation it is possible that fodder crops may be grown by the dairy society itself, or by an agricultural society to supply its demand, but the suggestion that, where municipalities have established or are about to establish sullage farms, fodder crops should be grown and co-operative dairies given the first call on these crops at market or even at favourable rates, appears to deserve consideration.

(3) The provision of bulls—especially buffalo bulls.

Bulls of good milking strain and buffalo bulls are difficult to obtain save in the westernmost parts of these provinces. The milking strain is therefore constantly deteriorating and fresh importation is continually necessary at heavy expense and there is a heavy drain on the breeding centres without return. If municipalities where co-operative dairies are in operation could keep bulls for the use of the societies, much improvement would result and at a later stage the societies would be in a position to pay for the bull's services or purchase bulls for themselves.

(4) The construction of model byres by the municipality on conditions of control over the sanitation observed and over the sale of milk. Low rates could be charged for occupation in the nascent stages of the dairy, to be increased as it consolidated its position. The society should be allowed ultimately to acquire the byres.

All these suggestions are open to the objection that the municipal aid invoked constitute uncommercial advantages and may prove artificial and transitory stimuli to the prosperity of the dairies, and that when their effect evaporates the societies may be unable to withstand the pressure of untempered economic forces. State aid is in general abhorrent to the pure gospel of co-operation, but it may, I think, be reasonably asked to abate the rigour of its tenets in the case of subventions in the forms above indicated,—all of which could be applied on fairly commercial lines.

NOTE ON LUCKNOW.

BY

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IT is not possible to fix the exact time when the city of Lucknow was founded. Its history is shrouded more or less in mystery, but there are several legends and sayings, the one finding most popularity being that Lucknow was founded on the site of a city founded by Lakshman, brother of Ram Chandra, the hero of Ramayan, supporting evidence being the fact that the high ground situated within the Machchi Bhawan is still known as the Lachman Tila. Aurangzeb after a visit to Ajodhiya came to Lucknow, and on one of the portions of this high land constructed the mosque still standing on the bank of the river Gumti close to the new bridge. Lucknow existed as a flourishing town in 1200 A. D. In 1478 A. D. the great saint of Lucknow, Shahmina, died. His tomb stands to the south of King George's Hospital, and even to-day attracts hundreds of Mohammedans from all parts of the province. It is said that a Mohammedan saint whose name was Sheikh Mohammad and who was a disciple of another Mohammadan saint, Haji Sheikh Zeauddin, who settled in Lucknow in 1396, was so displeased with the city as to predict that it would be demolished at an early date. The great saint, Shahmina, in reply, said that should such a state of affairs come to pass, only one portion of the town would show signs of decay while the other portion would prosper : this prediction has come true. Lucknow rose to great importance during the reign of the Emperor Akbar who had a special liking for the place, and his name is associated with several landmarks which will ever remind us of the interest that Akbar took in Lucknow. It was in the Great Emperor's time that Oudh became a separate principality with its head-quarters at Lucknow, but it was not until 1732 A. D. that the Oudh dynasty was founded by Saadat Khan, a Persian merchant from Naishapore, who rose to high power and influence at Delhi. Being successful in securing the Emperor Mohammad Shah's freedom from Bara Saiyid, he received the title of Burhanulmulk and became the founder of the Naishapuri Kings of Oudh. Saadat Khan lived chiefly at Ajodhiya, but in Lucknow he built many portions of the town in the north and on the other side of the river founded a Ganj which soon disappeared and only the ruins of a mosque here and there remain to tell us that it was once a prosperous mohalla of the city. Saadat Khan built many Katras in different parts of the city, the principal of which are Abu Turab Khan, Bagh Maha Narain in the Chauk, Katra Khudayar Khan and Bizon Beg and Serai Mali Khan in Daulatganj, and others. His successor Nawab Asafuddaula transferred the seat of Government from Fyzabad to Lucknow, and to him we also owe many of the mohallas of the town, the most important of which are known as Wazirganj, Amaniganj, Fatehganj, Rekabganj, Daulatganj, Begamganj, Nakkhas Tikaitganj, Bazar Jhao Lal, Balakganj and Kashmiri Mohalla : some of them were, however, actually built by his ministers or other high dignitaries of the State. Among his successors a few also founded new mohallas. Saadat Ali Khan's name is connected with Saadatganj, Rekabganj, Jangliganj, Maqbulganj, Golaganj, Maulaviganj, and Rastogi Mohalla. Amjad Ali Shah's name is connected with Hazratganj and his minister and tutor Amin-uddaula built the Aminabad bazar.

Lucknow has continued to expand steadily. In every decade one or two new mohallas were added by successive kings and many of them are in a flourishing condition even now. Lucknow, according to the last census, has a population of 240,116. This is a big falling off from 284,779, the estimated population of 1869. The density of the Lucknow population is much less than in other populous cities of the United Provinces, notably, Cawnpore and Benares. The decrease in the number of inhabitants is due to the contraction of the municipal limits, as also to the havoc caused by epidemic diseases. There is no retrograde tendency on the part of the population. In fact just the opposite, as the city is fast becoming popular as a place of retirement for Anglo-Indians and Mohammedans in Government service, who prefer a city which has so many attractions, to their home towns after

etirement from public life. The population consists of $\frac{3}{5}$ths Hindus and about 90,000 Mohammedans of whom one-third are Shias. Of the Mohammedans, about 11,715 claim to be Mughals and 17,000 Syeds. Among the Hindus the predominating castes are Brahmans, Rajputs and Kayasths. The town has become a centre of missionary activity due to the growing Indian Christian population.

The famous buildings of Lucknow have been the subject of adverse criticism or praise according to the taste of different European visitors to the town. They, however, attract hundreds of sightseers, both Indians and Europeans. From the Indian point of view, the largest and most important building is known as the Imambara of Asafuddaula. It was built as relief work in 1784. The building consists of a single hall 162 feet long by 53 feet 6 inches wide, and is said to have the largest unsupported arched roof in the world : it cost a crore of rupees and Asafuddaula's body is buried in it.

Husainabad, which adjoins the Asafuddaula Imambara, was built by Mohammad Ali Shah, who also built a big mosque known as the Jumma Masjid. The Imambara has been endowed with an income of Rs. 1,50,000 per annum which goes to support the Imambara of Asafuddaula, the tomb of Saadat Ali Khan and the Jumma Masjid, the last named was thoroughly repaired a few years ago at a cost of Rs. 40,000 ; Rs. 24,000 of which was given by the Government of India. Round the Husainabad bathing tank the Husainabad Trust has laid out a beautiful park. On the south of the tank is a picture gallery where life-size oil paintings of the late Kings of Oudh are a source of attraction to visitors.

The Residency, which was built by Nawab Asafuddaula in 1780 A.D., is one of the places of great interest in Northern India. Its grounds are picturesque and well maintained and the place will ever live in history because of the sacrifices made by Englishmen and English women in the defence of the town, and where at the time of the mutiny, Englishmen and Indians fought side by side against forces which, had they been successful, would have put an end to all the progress and advance which the town has made during the past 60 years.

From the grounds of the Residency one can see the Chatter Manzil Palaces built by Ghaziuddin Haider. On the south of the Chatter Manzil stands the Kaiserbagh, the construction of which was finished by Wajid Ali Shah in two years 1848—50, at a cost of 80 lacs of rupees. The tombs of Saadat Ali Khan and his wife stand at the northern end of the Kaiserbagh from where one can see the Tara Wali Kothi, built by Nawab Nasiruddin Haider as an observatory. The Khurshed Manzil next to it is now occupied by the Martinière Girls' School, while to the north of the Khurshed Manzil is the Moti Mahal, now the residence of the Maharaja of Balrampur : it was built by Nawab Saadat Ali Khan.

On the banks of the Gumti, a short distance from the Moti Mahal, is situated the Shanajaf, which was built by Nawab Ghaziuddin Haider, and he and his wife are buried there. This building is endowed with an income of about Rs.3,000 a month. Sikandarbagh known as the Horticultural Gardens, and the Wingfield Park are old gardens now used as places of public resort and both are maintained from State funds. On the south-east of the Wingfield Park is situated La Martinière, built by General Martin, a French merchant. The building was erected, some say, at the request of Nawab Asafuddaula, another allegation being that General Martin built it as a residence for himself. Nawab Asafuddaula was unwilling to pay a crore of rupees for the building and General Martin therefore left a will directing that the building should be used as a school for European and Indian students. On the east of La Martinière is situated the Dilkusha garden and to the north-east on the banks of the Gumti, the Bibiapur Kothi which was built by Nawab Asafuddaula to serve as a country residence.

This very brief description of the buildings in Lucknow will not be complete without mentioning later additions which have added to the attractiveness of the town. Round the Asafuddaula Imambara, a large tract of land measuring over 300 acres, once densely populated, had to be cleared for military purposes during the Mutiny, and on those grounds was first laid out an extensive park which has been followed by the magnificent buildings of the King George's Medical College and Hospital. In the garden known as the Badshahbagh across the Gumti, the new buildings for the Canning College have been constructed, together with a hostel, and adjoining the Canning College, buildings have been constructed for the School of Arts and the Nadwatul Ullma, while there is the Colvin institute for the sons of the Taluqdars of Oudh opposite the Canning College. Among other new buildings mention must not be omitted of the Judicial Commissioner's Court, which is possibly the only Court-house other than the new Munsiff's Court constructed by the British Government in Lucknow. Almost all other public offices are accommodated in old buildings which have, however, undergone many alterations to make them suitable for the purposes to which they are at present devoted.

Lucknow is well provided with bridges over the river. The oldest bridge was the Badshahi bridge, built by Nawab Asafuddaula close to Machchi Bhawan. This was recently demolished and in its place a bridge of ferro-concrete has been

constructed, which was the other day opened by His Excellency the Viceroy. The iron arch bridge was put up in Nawab Amjad Ali Shah's reign, though its pieces were brought to Lucknow by Nawab Nasiruddin Haider. Bruce's bridge was constructed by the Provincial Public Works Department, so was the iron girder bridge. We have also two railway bridges for the two gauges of the railways passing through Lucknow.

In the pre-British administration there was no constituted body to look solely to the affairs of the city, no minister in special charge of the city, the affairs of which were administered by the same central authority which ruled the rest of the province. A system of octroi duty on all imports in the town existed, but it was more like a transit duty than a tax levied for local purposes. If no special fund was earmarked for local purposes the needs of Lucknow as far as public buildings were concerned were met by the State Exchequer. Shortly after the Mutiny the Local Agency and Municipal Committee came into existence. The duty of this Committee was to administer Government nazul lands in the city and to carry on the municipal administration. On the 1st January 1862, a separate body called the Municipal Committee of Lucknow was formed, which consisted of officials and non-official members entirely nominated by the local Government. This Committee continued to exist till the 14th September 1884, when the present Board came into existence under the scheme for local self-Government. There are few of the achievements of the old Municipal Committee which can be singled out as permanent landmarks to remind us of the 22 years of its existence. The Committee improved the drainage of the town by constructing some big drains to which were connected the old underground drains, but the work done was so defective that the entire system had to be changed. The big drain known as the Sarkata Nala, which serves the purposes of a sewer and storm water drain for the western part of the town, gives us some idea as to the drainage scheme which forty years ago was considered sufficient to meet the requirements of the entire population of two of the most thickly populated wards of the city. The area of the Municipality of Lucknow, excluding Cantonments, is 19·61 square miles with about 80 miles of metalled roads. What the Municipal Board, as at present constituted, has been able to do since it came into existence 30 years ago can be better appreciated if we first try and realise the sanitary condition of the city prior to its constitution. Dr. Reginald Heber, Lord Bishop of Calcutta, made a journey through the upper provinces of India from Calcutta in the winter of 1824—25 and in October 1825 he paid a visit to Lucknow. He rode on an elephant between Mir Hasan Khan on the right and Captain Solomon on the left, while a motley multitude preceded them and spare elephants followed. He gives the following description of Lucknow as he found it then :—

"We advanced into Lucknow through a very considerable population and crowded mean houses of clay with the filthiest lanes between them I ever went through and so narrow that we were often obliged to proceed in single file and even a single elephant did not always pass very easily * * * as we advanced the town began to improve in point of buildings, though the streets remained equally narrow and dirty."

Two years later Captain Munday, A. D. C. to Lord Combermere, the Commander-in-Chief in India, paid a visit to Lucknow and was struck with the narrowness of the streets of the city and with the number of wretched looking beggars.

Tenant visited Lucknow just after Nawab Asafuddaula's reign when the splendour of Lucknow was at its highest zenith. He gave the following description of Lucknow :—

" I yesterday went to view this capital which is said to contain half a million souls. Happening to enter the town at the west and which contains the poor mechanics and labourers of every sort, I never witnessed so many forms of wretchedness, filth and vice. The streets which lead to the Palace are upwards of five miles long, more than one-half of which you wade through mire and filth. During the lapse of time the streets sink from cleaning or by the blowing away of dust while dry, so that they are fallen in the middle to the depth of ten or twelve feet and are so narrow that two hackeries cannot pass nor indeed any carriage, however small. My palankeen was frequently stopped by the small asses which were passing along loaded with bricks. This animal is here so slender that a stout porter could have no difficulty in literally carrying both the beast and its burden. Solomon must have employed an immense number in carrying the materials of the Temple, if his asses were not of a superior breed to those of Lucknow." Then it is not only foreigners who gave an account of Lucknow which would not rouse feelings of local patriotism in the citizens.

Indian writers and poets were not less frank in their description of the town. Beni, a well-known poet and satirist who flourished under the patronage of the well-known Hindu minister, Maharaja Tikait Rai, gave a description of Lucknow which will be read with feelings of amazement. The English translation of one of his well-known Hindu poems runs as follows :—

" The mire of Lucknow is so bad and deep that horses halt at it, elephants get stuck in it, camels get cramps at it, and a cow gets into difficulties at the mere

sight of it. If one by mistake puts one's foot in it, after taking up the skirts of one's garments, one is lost in the mire and only one's turban can be seen." The poet Beni adds that " a man shivers at its sight, there is no way for chariots and even a bullock gets into difficulties in it," and then he says: "O Creator, I invoke Thee again and again, I accept death willingly as an alternative to the mire of Lucknow."

* The mangoes of Lucknow have so spoilt the roads of the city, the poet adds, that they flow like big drains and thus the mangoes have become the enemies of the clothes of the citizens. Even on the days of entertainments when gentlemen collect together, the terribly bad smell of the drains pervades the atmosphere and makes them quite uneasy. The mosquitoes of strong and tyrannical tenacity never leave one's ears and continually fly near them making horrid noises. They are in such vast numbers in this compound in particular that they seem to have been produced by the trees showered from them or as though new mines of them have been opened up.

The pictures given above might be considered to have been overdrawn by the poet, but one can form some idea of the conditions prevailing in Lucknow before the organization of the Municipal Board.

This body is solely responsible for the sanitation of the town and a few figures only will give an idea of what it has done for its sanitation. Besides its savings from revenue, the Board has sunk Rs. 25,91,000 in carrying out several schemes of extensive waterworks and drainage. Practically the whole town has been provided with an up-to-date supply of filtered water and a large portion of the city drained on modern lines.

Mr. P. R. Hewlett, Supervising Engineer, in his note gives an account of the drainage system of the town and describes at some length the several schemes carried out by the Board. A note by Mr. H. T. Carter, Superintendent, Water Works, contains a brief account of the water-supply system in Lucknow.

Having regard to the resources of the Board, it spends quite a good percentage of its revenue on the conservancy arrangements of the town. To look after the convenience of 240,000 people, the Board spends over a lac and a quarter on the conservancy of the town and employs a staff of 1,264 persons. It maintains 110 latrines, 127 dust-bins and 19 urinals. It spends over a lac and a half on the maintenance of its roads and on public works. The Board has a net-work of Primary schools in the town, and every parent who is anxious to send his son to school has no difficulty in doing so. Lucknow has a number of well provided State and aided dispensaries and hospitals. These have been supplemented by the Municipal Board by founding its own dispensaries in different parts of the town, so as to place them within easy reach of the people.

A paper on the city of Lucknow will not be complete without some reference to the several town improvement schemes in which the Board has been engaged for the past seven years.

The first improvement scheme of any magnitude worthy the name was the opening of the La Touche Road. This was brought about by a memorial from the residents of Aminabad and the neighbourhood who were anxious to secure a through road to the principal railway station in Lucknow, Charbagh, and at the same time to open up the land for a park in Aminabad. The memorial clearly showed what the ideas of the residents who signed it were, and Sir James La Touche inspected the site during his monsoon tour of 1905 and decided that the road should be constructed from provincial revenues and the park carried out at the expense of the Municipal fund. Regarding the road little more need be said. The scheme was carried out entirely by Government agency, and I have no figures or particulars at my disposal from which I can comment on the scheme. The Aminabad Park scheme as originally proposed covered the whole area which has finally been included therein, but when the estimates were prepared it was thought that the Municipal funds could not stand the strain and the scheme was modified to include only the portion where the park has been laid out, the roads round it and the two shops at each end adjoining the Aminabad Road. When the revised scheme had advanced to this stage and the sites of these shops were sold, the return was so good that it was decided to go on with the scheme as originally proposed and finally nine acres of land were acquired at a total cost of Rs. 1,59,649, out of which 3 acres were sold as sites for combined shops and dwelling houses for Rs. 1,85,628. The profit thus obtained was devoted to the construction of the Park, clock tower, roads, stalls, etc. Throughout the period occupied by the carrying out of this scheme, only Rs. 10,000 was taken from Municipal funds and this sum was subsequently refunded. Irrespective of the profit on the scheme, the Board has in its possession 52 road-side stalls, bringing in an annual income of about Rs. 3,000 and the Park, road and lane lands.

The buildings surrounding the Park and facing La Touche Road have all been built to a standard design as far as their frontage is concerned. The lower storeys

* In the mango season people suck the juice of the mango, throw the skin and seed on the roads which, if not promptly removed, make the roads slippery.

are used as shops and the upper storeys which have a nice wide balcony are used as residential quarters. They have rented readily and there has been no paucity of purchasers when any of the buildings have been sold, the rates obtained being eminently satisfactory to the sellers.

The next step in any organised improvement was the grant of Rs. 2½ lacs made to Lucknow, Cawnpore and Allahabad by the local Government for the opening of congested areas, and for the administration of which grants the local Government created in each town what is now known as the "Improvement Trust." Our Trust consists of five members, including the Chairman of the Municipal Board. A deed has been drawn up between the Trust and the Secretary of State for India and the Trust administers the fund and also supervises all executive matters.

The scheme for opening up congested areas in Lucknow consisted of the construction of a 60′ road from east to west of the city, commencing at Abbott Road and ending at Alamnagar in the south-west and Napier Road in the north-west, the bifurcation being effected at a point close to Ranikatra in the Daulatganj ward. Sufficient land on either side of the road was included for the erection of decent buildings. The scheme was divided into 7 sections, the first extending from Abbott Road to La Touche Road, the second from La Touche Road to the Aminabad Road, the third from the Aminabad Road to Canning Street, the fourth from Canning Street to Victoria Street, the fifth from Victoria Street to the Akbari Darwaza and the sixth from Akbari Darwaza to Napier Road, a branch road being taken off at a point near Ranikatra to Alamnagar which is known as the seventh section.

The original alignment was adhered to as far as possible, but considerable alteration was found necessary as work progressed. On the first section, now known as the Hewett Road, extra low-lying land was included west of the Jhuria Tola crossing as it was considered inadvisable to leave low land within such close proximity to the new road. Including sewers, roads and pavements this section has cost Rs. 89,519, while the total return, excluding the value of road and lane lands and the open space adjoining La Touche Road, was Rs. 76,540.

The second section was not so profitable as the total cost came to Rs. 57,783, against a return of Rs. 24,815, but the cloth market scheme was, at my suggestion, added to this section and the above deficit was considerably reduced thereby, as the market cost only Rs. 57,247 and the return was Rs. 81,483, while the Board retains land in the centre of the market and in roads and lanes to a value far exceeding the deficit, besides being in a position to enforce the removal of the old cloth market, a very necessary reform which the Board has taken up as a separate scheme and which has been approved by the present Lieutenant-Governor, His Honour Sir James Meston.

The alignment of the third section underwent considerable change. Originally it was designed to take off where the second section ended and to pass through the Aminuddaula Serai, but this was found to be a very costly line, and as it was necessary to take up the Aminuddaula Bagh to clean up the land opposite the Aminabad Park and to widen the Aminabad crossing, it was eventually settled that this section should take off opposite the southern corner of the Aminabad Park and travel practically due west to the bridge on Canning Street over the narrow gauge railway. Even this alignment was a costly one, but it was considered very necessary as it provided a direct through route from the western portion of the city to the public offices, etc., and to make this route even more useful a branch road known as the Pir Jalil lateral was opened at the north-western corner of the Aminuddaula Bagh near the Aminuddaula mosque. The Aminuddaula Bagh, together with another garden adjoining it which faced the Aminabad Park, have been retained by the Board and converted into a park with stalls on the side adjoining the Aminabad Road, while the road between the two parks has been widened to 100 feet. These stalls will fetch an annual income of Rs. 3,000. At the corner of this Park near the Aminabad crossing a large C. I. hackney carriage stand, properly drained and paved with stone sets and capable of holding 50 carriages, has been constructed and fulfils a long-felt want as the congestion of traffic at this point needs to be seen to be realised. The buildings south of the Aminuddaula Park near the Aminabad Road end are of the same design as those round the Aminabad Park ; from the Goongey Nawab Garaya onwards, no special design has been insisted on, but only buildings of which the design has been approved by the Trust Committee may be erected. The bridging of the Moulviganj main drain and the Subhannagar Road helped to enhance the cost of this section, and from the Moulviganj bridge to Canning Street it was found impossible to arrange for sites of any value, with the result that the return was very small ; but in calculating the return it must not be forgotten that besides road and lane lands, the Board retains the whole of the land in the Aminuddaula Park and gave two larger sites at cost price for school buildings. Including roads and bridges, this section has cost Rs. 5,09,798, while the income amounts to Rs. 2,86,332 only. The local Government, however, was pleased to make a further grant of one lac of rupees which enabled the Trust Committee to continue its operations and the fourth section is now well in hand.

This section takes off opposite the third section and travels practically in a straight line to Victoria Street. The original alignment has undergone very little change, but it was thought advisable to bring in the Agha Mir Serai to provide a park for this portion of the town. There was a group of Bhatiaras spread over this serai who have been allotted sites on the acquired land and are building quarters for themselves to standard plan fixed by the Board.

Demolition of acquired buildings is proceeding rapidly, and the acquisition of the whole section should be finished by the end of this month. It has been decided that no site on this section shall be sold until the land has been cleared, the sites marked out and the road laid, as it has been found that unless this is done, the prices fetched are not good. The step means locking up capital and the local Government has therefore very kindly advanced two lacs of rupees to the Board to tide over this difficulty.

As regards the remaining sections little can be said beyond that the surveys have been completed and the acquisition estimates are under check.

Of the benefits accruing from this scheme much might be said, but to be fully appreciated a knowledge of the state of affairs that existed prior to the opening of the road would be necessary. The third section, long before it was properly metalled, was utilised to its full extent by foot passengers, but since the road has been thrown open to vehicular traffic the steady stream of carriages passing up and down it, especially in the evening, is a sight worth seeing.

Side by side with the foregoing improvements the Board on its own account has been very busy with many other improvements, both large and small. Principal among these are the Saunders market, Ganeshganj grain market, Model House scheme and Civil Lines extension.

The Saunders market, which has been erected on a triangular plot of land formed by the junction of the Cantonment and La Touche Roads, was designed by the Sanitary Engineer to Government, and has now been added to by the erection of a block for the sale of beef. The main building provides for mutton, fish, eggs, poultry, etc., while across the road a vegetable market has been started, the extension of which the Board hopes to provide for during the coming financial year. The main building has yet to be fitted with automatic closing doors and needs one or two other minor improvements. It has enabled the Board to do away with a large number of insanitary meat shops within a certain area, but experience has shown that it is on too large a scale for efficient public service and small mohallas or ward markets would probably be more useful.

The Ganeshganj grain market besides doing away with a most unsightly and insanitary spot will, when completed, provide one of the most necessary wants of the town, as the present market in Fatehganj is insanitary to a degree and being privately owned under a 'sanad' from Government, is susceptible to little, if any, control.

The Model House scheme is nearing completion as far as the Board is concerned. The only item remaining to be completed being the sewer, the scheme for which is with the Sanitary Board. Model houses were erected by the Board in accordance with the plans provided by Government and these are rented regularly. Purchasers of sites, however, have not been at all keen on constructing their houses to these plans and the Board has not pressed the point, being content with decent sanitary dwellings.

The Civil Lines extension has been completed with the exception of the drainage, and the houses are fast springing up, some of them already being in occupation. The area affected has been named Butlerganj after our worthy President who was closely associated with the scheme while serving as Deputy Commissioner of Lucknow. The people unhoused by this scheme were located on nazul land across the river in a model basti now known as Boasganj. The basti only needs drainage and road metalling to make it sanitary in every respect. During erection care was taken to leave plenty of space for roads and a large open space in the centre. Arrangements are being made for a branch dispensary and a school, and a small market of 6 stalls will be erected there shortly. When these improvements have been carried out, this basti will be self-contained to a degree which no other part of the town can boast of.

Much more could be said of these improvements, but I have already taken up considerable space and will content myself with a few general remarks regarding other improvements. The Hazratganj pavements which we owe to our worthy President have made this important thoroughfare the cleanest in the whole town, while the weir for which we are indebted to Sir John Hewett, has given the town a river frontage which it sadly needed. We are also indebted to Government for the removal of the Cheda and Ghasi Ram Purwas, a much-needed reform, as these places were nothing more or less than a haven of refuge for women of ill-fame. The construction of the Hazratganj Police Station and the Jehangirabad mansions have cleared up the old Hazratganj bazar or market to a great extent, but much more remains to be done before this part can be called anything like sanitary. The

transfer of the conservancy cattle and cart lines from the heart of the eastern portion of the city to the other side of the river has settled a long standing complaint. All this has only been achieved through the cordial co-operation of both the official and non-official members of the Municipal Board and its staff, and the excellent relations existing between the Municipal Corporation and the citizens of the town whose interests have been very jealously guarded by their representatives in keeping the incidence of taxation as low as possible. It is the lowest of all first-class towns, being Rs. 1-12-0 per head of the population.

A SHORT DESCRIPTIVE NOTE ON LUCKNOW CITY SANITATION.

BY

MR. P. R. HEWLETT, A.M.I.C.E.,

Lucknow.

General.—Before the present system of drainage was commenced, there were existing deep storm water nallas which also received the sullage from the surface drains which had been constructed at various times. These surface drains were of a very inferior nature, and it was not until Mr. H. Lane-Brown was called on in 1904 that any comprehensive scheme of drainage was undertaken. It was then decided that under no circumstances could pumping be considered, and Mr. Lane-Brown was instructed to find some means by which it could be dispensed with.

A scheme was prepared in which the new main drains practically followed the course of the old storm nallas, but at higher levels, thus obtaining sufficient fall for purification works at each outfall.

Although the first of these purification works proved very successful, the smell given off at such works was a public nuisance owing to the proximity of a busy thoroughfare and as all the outfalls were unfortunately at similar sites, it was decided to adopt some other method of dealing with the crude effluent.

Two intercepting sewers were therefore constructed in 1909, the one intercepting the Maulviganj, Ghasiari Mandi and Husainganj sections, and the other the Patanalla with provision for the Sarkatanalla section.

The first discharging on to waste land behind Wingfield Park and the second on to cultivated lands behind the Clock Tower Gardens.

Owing to the great value of the land at this area, and difficulties with the owners, it has been decided to provide a farm or farms across the river in place of the existing ones.

Division of Scheme.—The scheme, as sanctioned, was divided into five separate areas. 1. Maulviganj. 2. Patanalla. 3. Husainganj. 4. Ghasiari Mandi. 5. Sarkatanalla (*see* Plate No. 2).

Of these, for purposes of accounts, Maulviganj and Patanalla were constructed together, as also Husainganj and Ghasiari Mandi; leaving Sarkatanalla still to be constructed. The total estimated cost of these being approximately 28 lacs.

Main Drains and Laterals.—Each area consists of one main drain with various sub-mains or laterals, which have been calculated to carry $\frac{1}{4}$ inch rainfall per hour with overflows to old storm drains. The total amount of water that can be carried off being two inches per hour.

A large proportion of the main drains as well as the laterals have been constructed as sewers and these are capable of dealing with a flow two inches per hour, and are fully provided with manholes and gully pits (*see* Plate No. 6).

Surface Drains.—Surface drains have been constructed in all foot traffic lanes of an equivalent ovoid type taking the sullage direct from the houses to the main drains.

The drains are constructed of kankar lime concrete with cement concrete surface, and are quite non-absorbent, besides having a very long life. Some of these drains have been moulded at Store and then laid in the work; whereas others have been constructed in situ.

Pavement.—These foot traffic lanes have also been paved with either brick, cement slabs or in situ, cement paving. For a long time the paving was done with brick, but after many experiments a satisfactory mixture of cement concrete was obtained and a large amount of this paving has now been laid and has proved much more cleanly than the brick.

Kerb and Channel Drains.—On vehicular traffic roads the surface drainage has been dealt with by means of kerb and channels, which in the first place was constructed of Mirzapur stone but latterly has been replaced by slabs of cement concrete manufactured in the same way as the paving slabs and also by some "in situ" cement concrete work.

These kerb and channel drains while dealing efficiently with the sullage are not liable to breakage, as the channel is laid in continuation of the curvature of the road way.

House connection.—As far as possible every house drain has been connected to these surface and kerb and channel drains so that in the complete areas all sullage is carried away.

Conservancy.—The great secret in the efficient working of a surface drainage scheme is provision of good conservancy, and while Lucknow is in advance of many cities in this respect it is by no means perfect. It is, however, improving daily and as a water carriage system is being slowly introduced along with the surface drainage the staff will be better able to cope with the work that remains.

Gradients.—It is in many cases, owing to the existing conditions, very difficult to obtain suitable gradients for surface and kerb and channel drains without going to very great expense in regrading roads and lanes.

A minimum of 1 in 300, however, has been the standard as far as possible and this has been worked to, unless very heavy expense incommensurate with the benefit would have been incurred.

Sewers.—Besides the previously mentioned intercepting sewers there are various lengths of brick sewers and stoneware pipe connecting with them, and although so far very few houses have been connected, it is hoped that in a few years' time, with the introduction of water flushed latrines and pail depôts (a few of which have already been constructed) and the extension of sewers and pipe lines, that the cartage of night-soil will be entirely done away with.

It will probably be possible to convert the existing open main drains into sewers and pipe lines can then be provided as necessity may arise.

Water Flushed Latrines.—A few latrines of "Palmer's Patent Mohalla" type have been constructed, and many more are provided to take the place of the existing ones from which the excreta is removed by carts. This type of latrine has proved very popular in many towns in India, and large numbers are being erected every year.

In the case of the Aminabad Latrine the discharge is through a short length of sewer to the Ghasiari Mandi open main drain and for this reason a liquefying tank has been provided so that only a liquefied effluent may be discharged.

Pail Depôt.—Pail depôts have been constructed at various points connecting with the intercepting sewers by means of pipe lines or existing branch sewers.

These depôts provide a quick and sanitary method of dealing with the night-soil collected from the houses by the mohalla sweepers. The basket being emptied on to a stout grating and the collection flushed through by means of a powerful stream of water directed on to it from a hose and nozzle attached to a 2" pipe.

Such fine mineral matter as may pass through the grating being removed from the detritus pit as may be necessary.

A light iron cover is provided to place over the grating when the depôt is not in use.

Urinals.—Many urinals are required throughout Lucknow and as soon as funds are available, it has been decided to construct as many as possible of type shown in Plate No. 7.

The particular point about this design is that a fine stream of water is always passing over the slab so that there is never any deposit and hence the urinal is absolutely free from smell.

Sanitary Roads.

In 1907 the removal of congested areas and provision of open spaces was considered and a large scale plan was prepared, and a general scheme for construction of sanitary roads from the eastern to western side of the city, starting at Abbott Road and finishing at Baoli beyond the Chowk. Various branch roads have also been proposed and will be taken up in due course.

Aminabad Park.—The Aminabad Park consists of a square, around three sides of which shops have been constructed to a type design with the fourth side opening to the Aminabad Road. The inner portion being laid out as a garden.

Cloth Market.—The cloth market is similar to the Aminabad Park, a short distance along the Aminabad Road.

Grain Market.—The Grain Market has been laid out on similar lines to the above and is on the La Touche Road. The roads around this, however, have been constructed of a sufficient width to allow ample accommodation for the carts when unloading.

Model Houses.—The area known as Gagni Shukal-ka-Talab has been laid out with roads for the construction of Model Houses and a few were built as samples from the design of Sanitary Engineer to Government. Although the area has been laid out and some houses constructed the drainage has not yet been taken in hand. A scheme for this has, however, been submitted to Government.

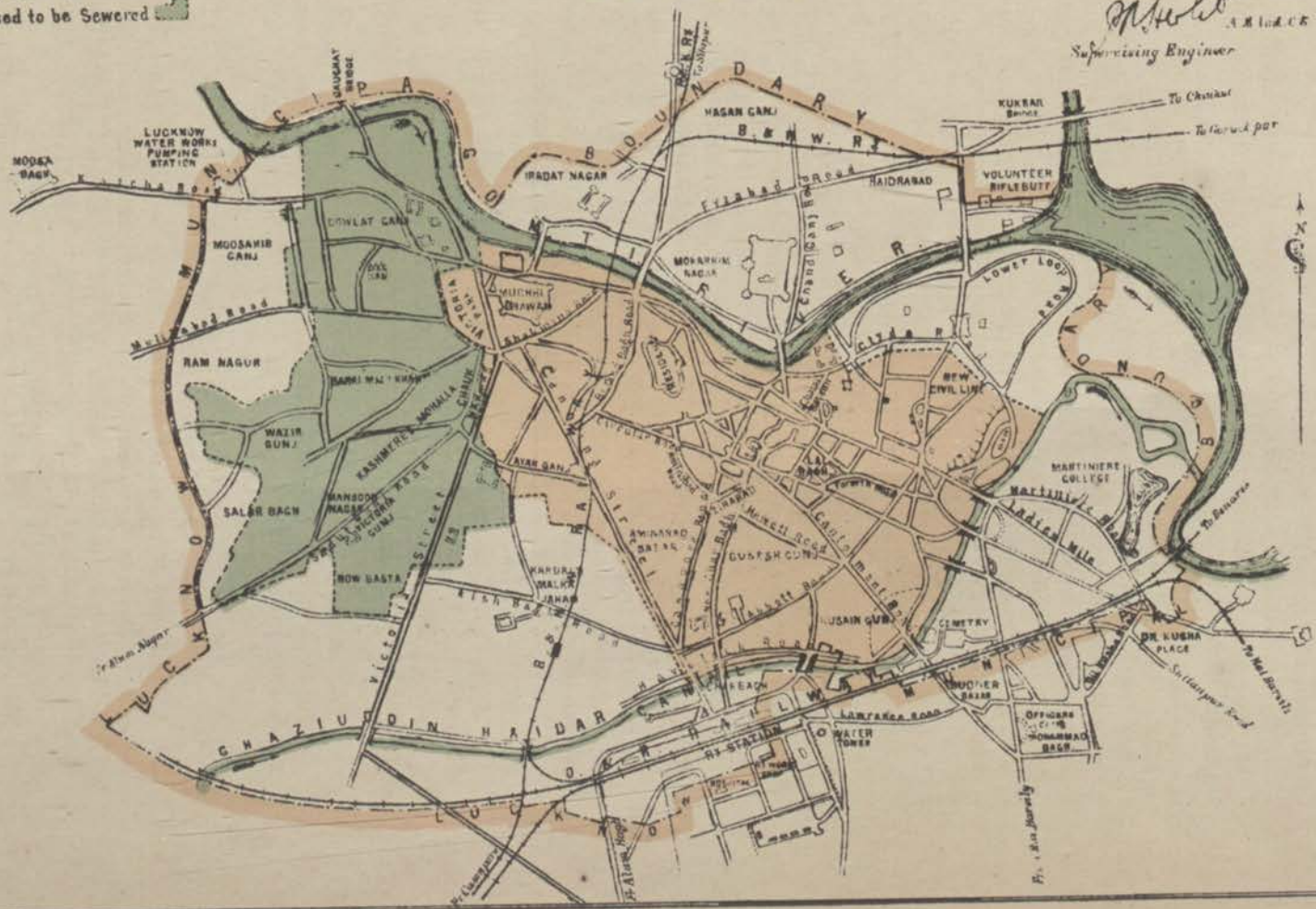
PLAN OF LUCKNOW
SHEWING AREAS ALREADY SEWERED
AND
AREAS PROPOSED TO BE SEWERED.

Scale 1 Mile To 4 Inches.

REFERENCES.

Areas already Sewered

Areas Proposed to be Sewered



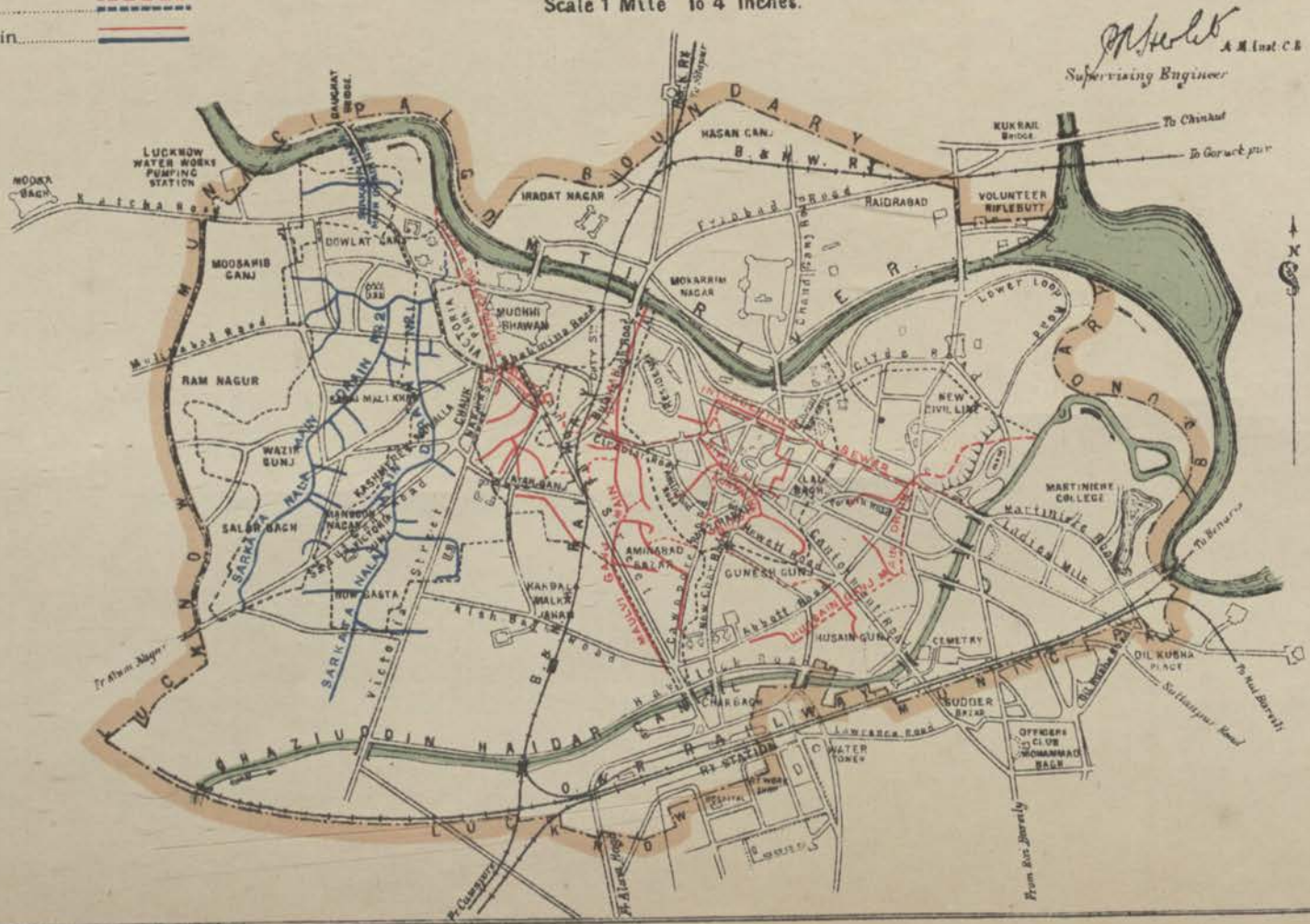
PLAN OF LUCKNOW
SHEWING DIVISIONS OF THE
MAIN DRAINAGE SCHEME.

Scale 1 Mile To 4 Inches.

REFERENCES.

Sewer.....

Surface Drain.....



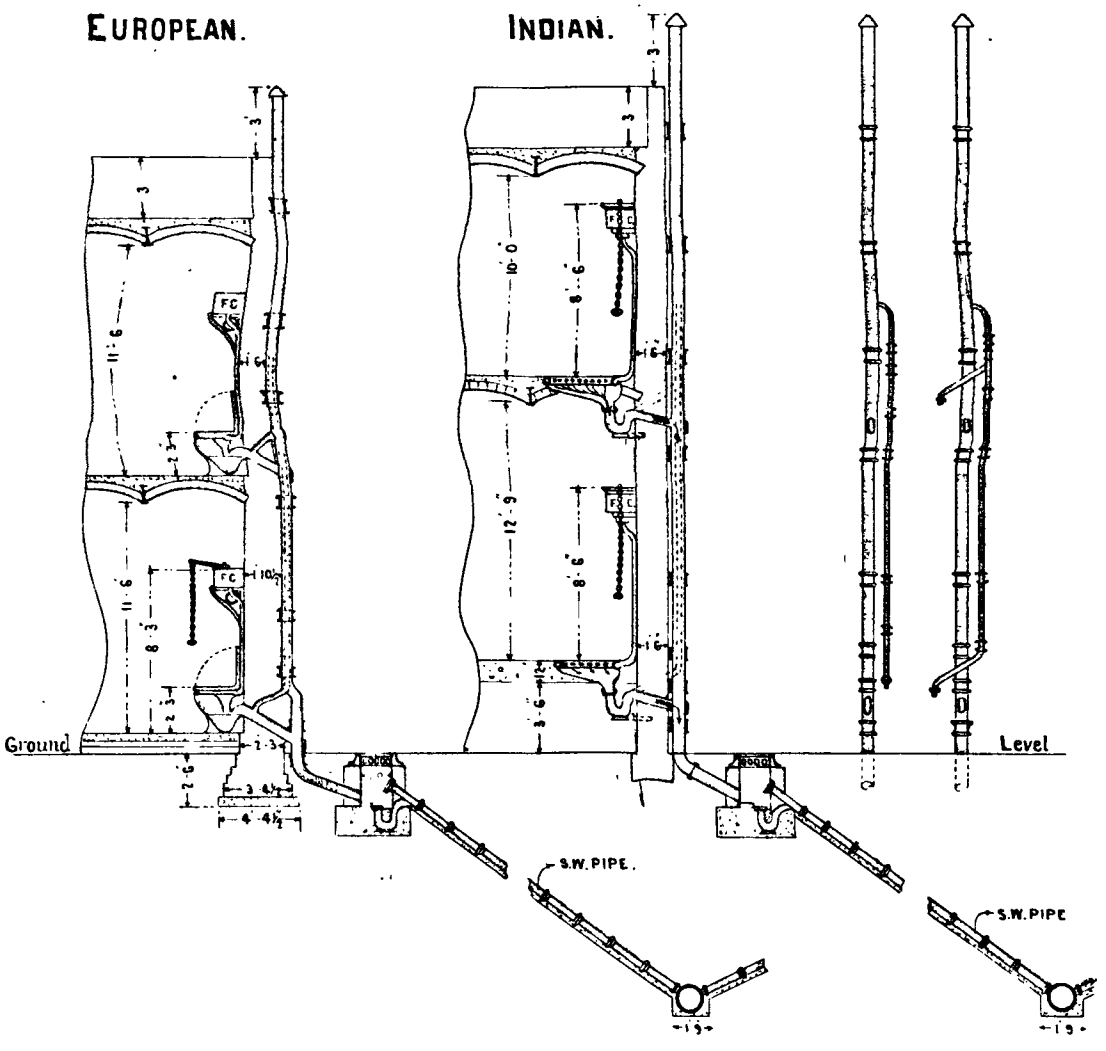
№ 3

TYPICAL HOUSE CONNECTION TO SEWER.

Scale 9·7F to an Inch.

A.M.Inst.C.E
Supervising Engineer

PIPE ELEVATION.

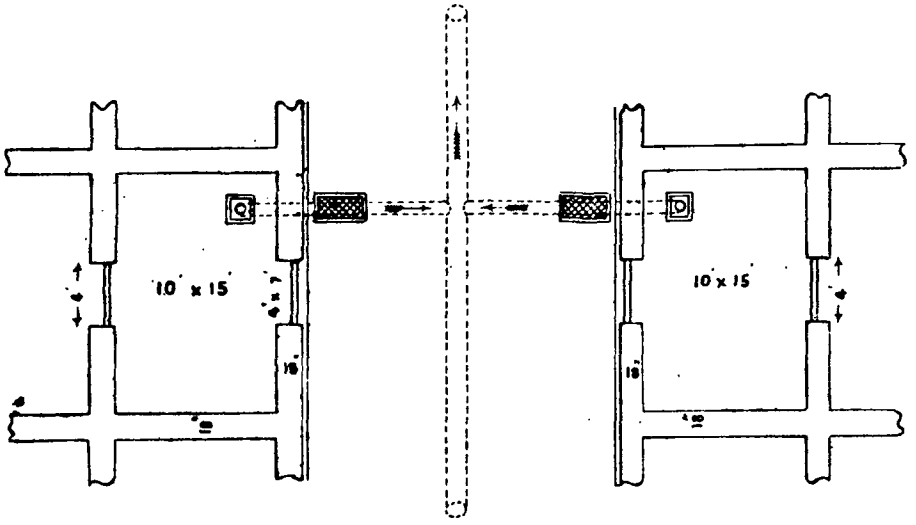


TYPICAL HOUSE CONNECTION

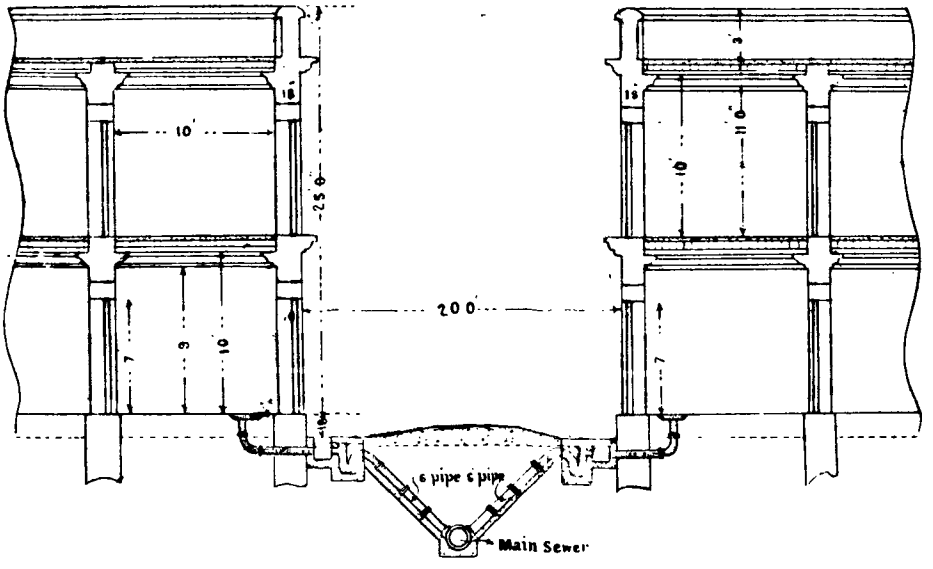
FOR SULLAGE WATER.

Scale 12 IF to an inch.

J. M. Heath A.M.Inst.C.E.
Supervising Engineer



PLAN.



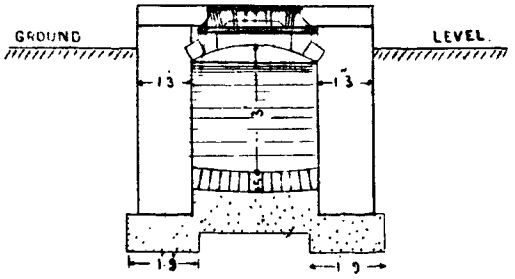
CROSS SECTION.

№ 5

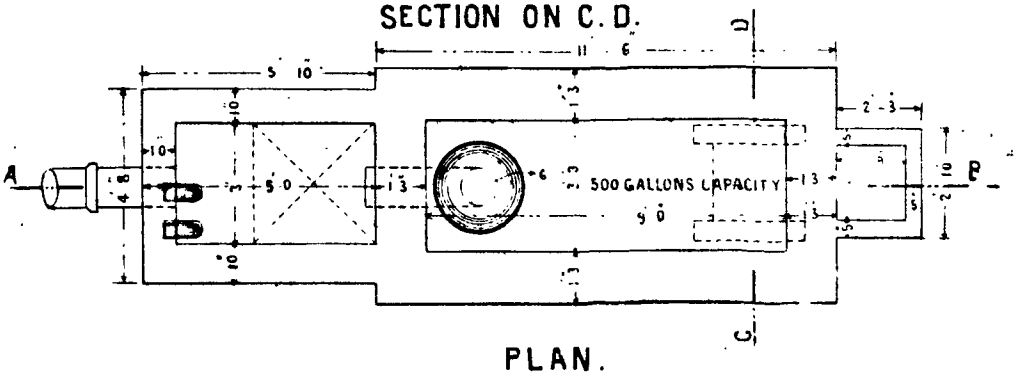
FLUSHING TANK WITH AUTOMATIC SYPHON

Scale 4·8 Ft. to an Inch.

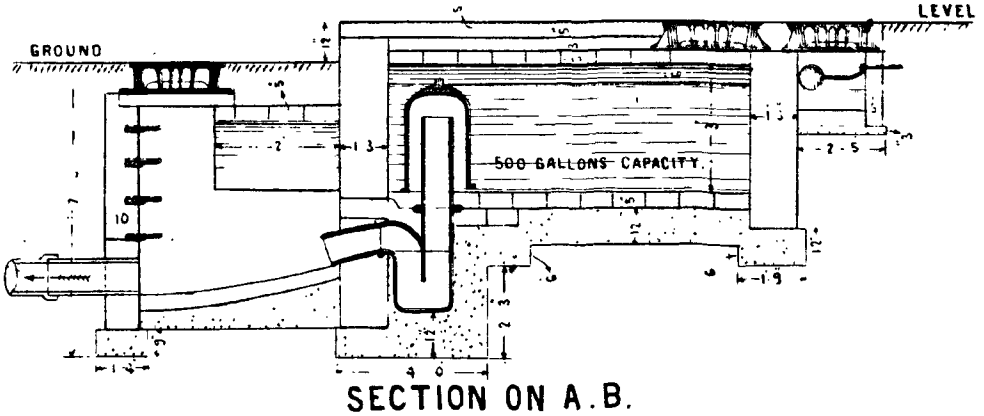
A.M.Inst:C.E.
Supervising Engineer



SECTION ON C. D.



PLAN.

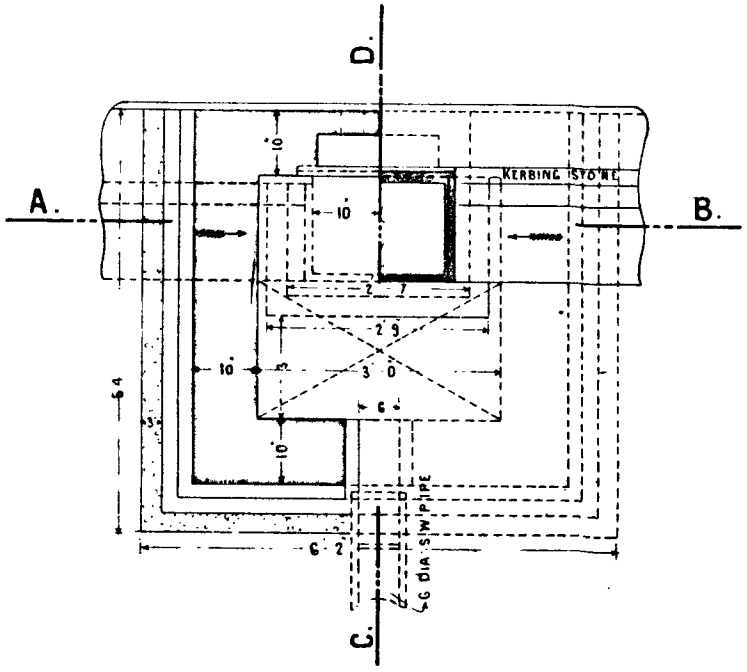


SECTION ON A. B.

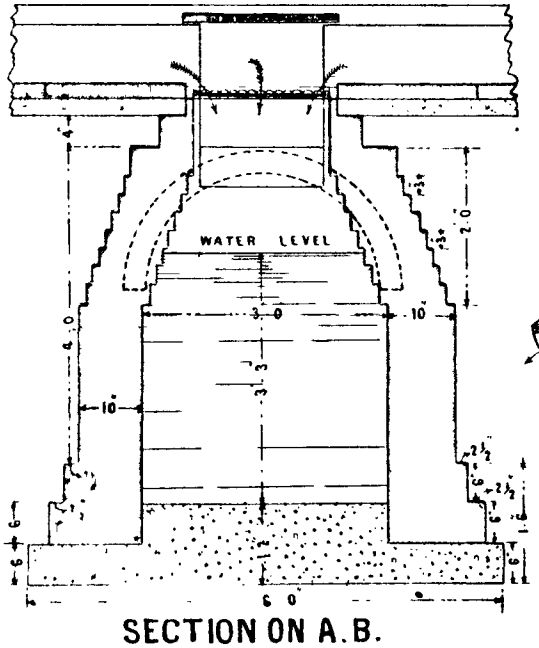
GULLY PIT SHEWING SEWER CONNECTION.

Scale 2·4 F to an Inch

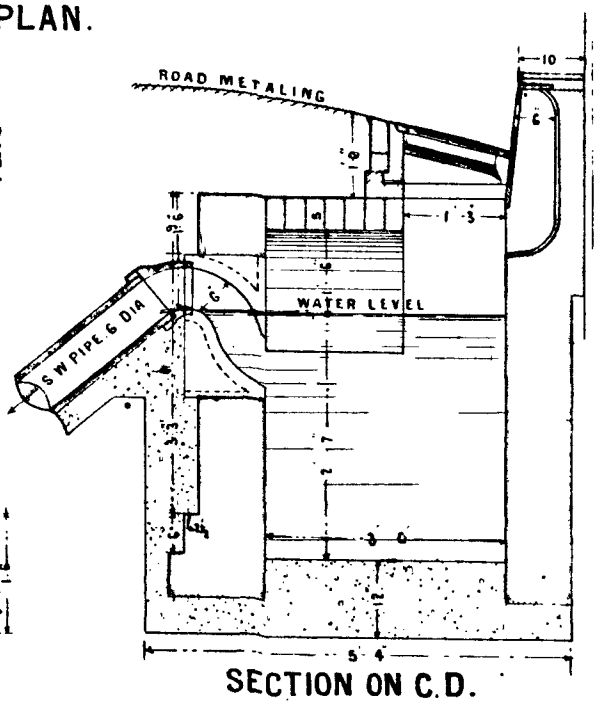
A.M.Inst·C.E.
Supervising Engineer



PLAN.



SECTION ON A.B.

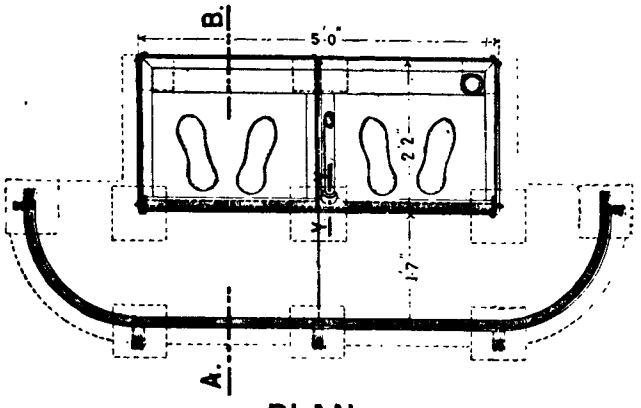


SECTION ON C.D.

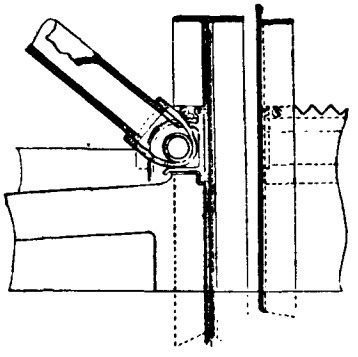
WATER FLUSHED URINAL.

Scale 1·2 FT to an Inch.

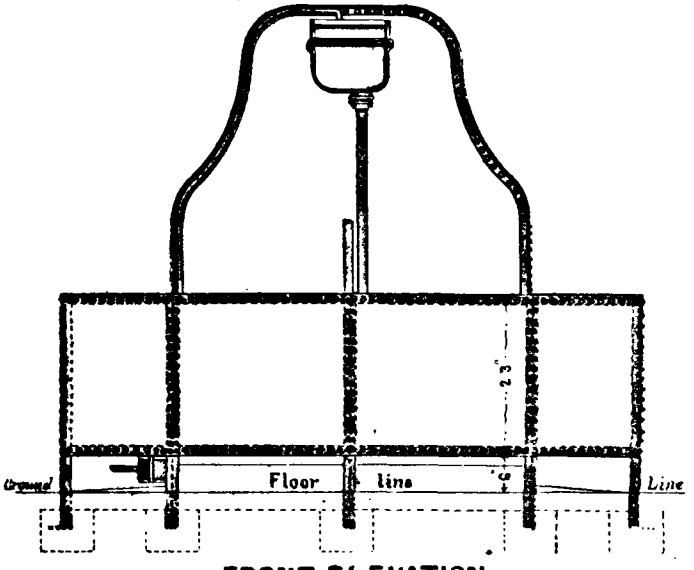
A.M.Inst.C.E.
Supervising Engineer



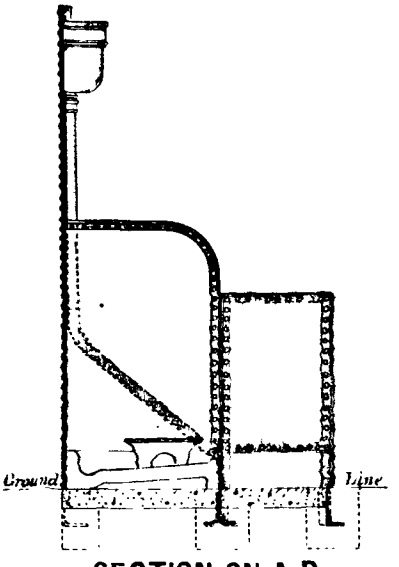
PLAN.



DETAIL SECTION ON Y.Y.



FRONT ELEVATION.

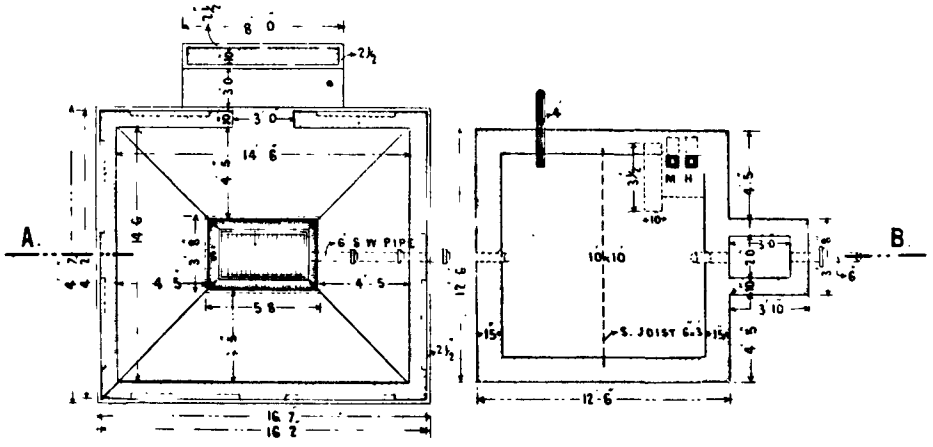


SECTION ON A.B.

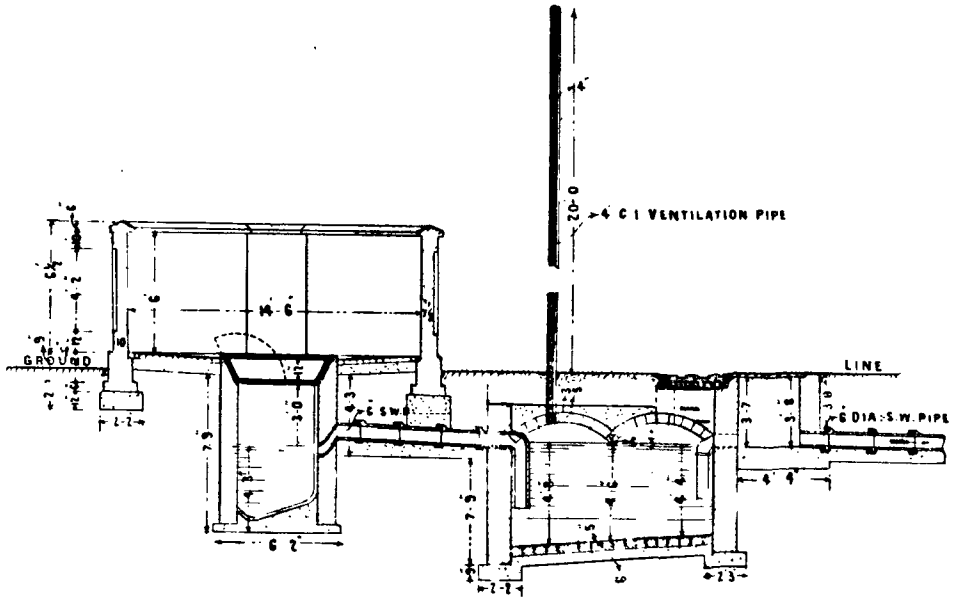
PAIL DEPOT WITH LIQUEFYING TANK

Scale 9·7F$^{T}_{H}$ to an Inch.

A.M.Inst.C.E.
Supervising Engineer



PLAN.

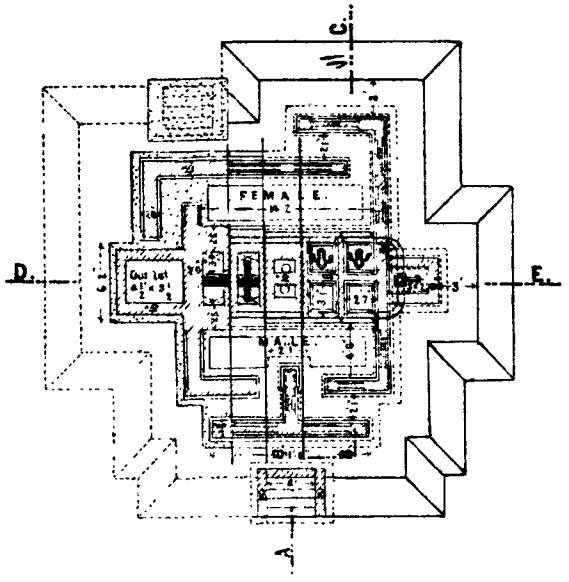


SECTION ON A.B.

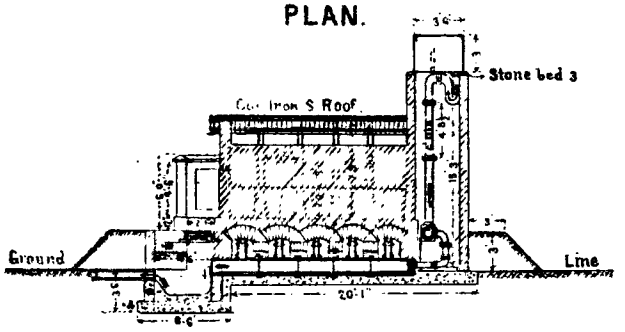
WATER FLUSHED LATRINE.

Scale 12 Feet to an Inch.

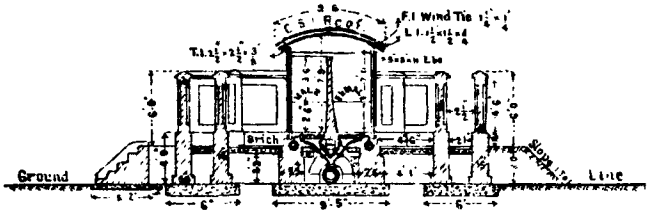
A.M.Inst:C.E.
Supervising Engineer



PLAN.



SECTION ON D.E.

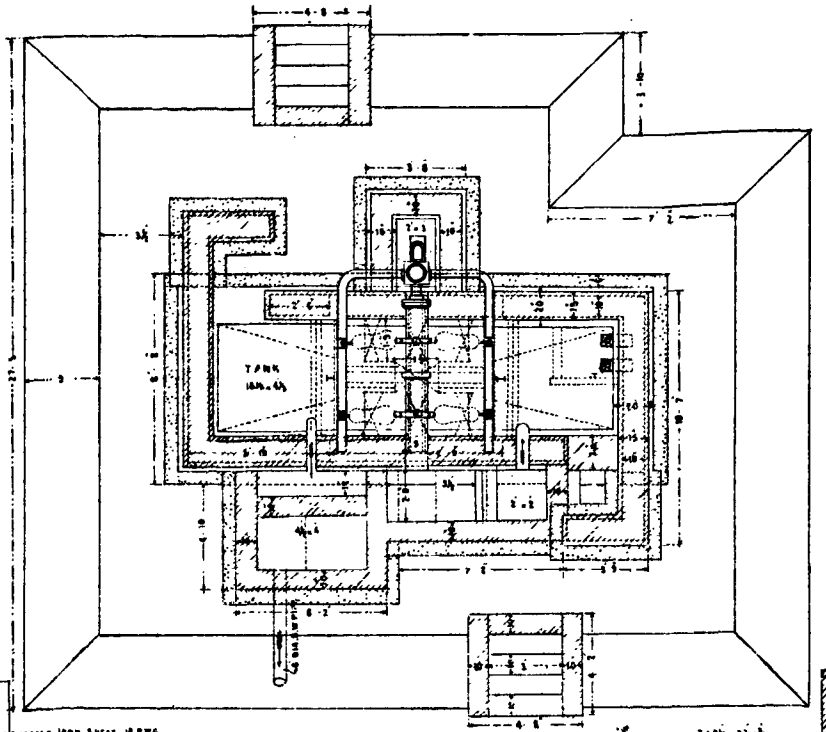


SECTION ON A.B.C.

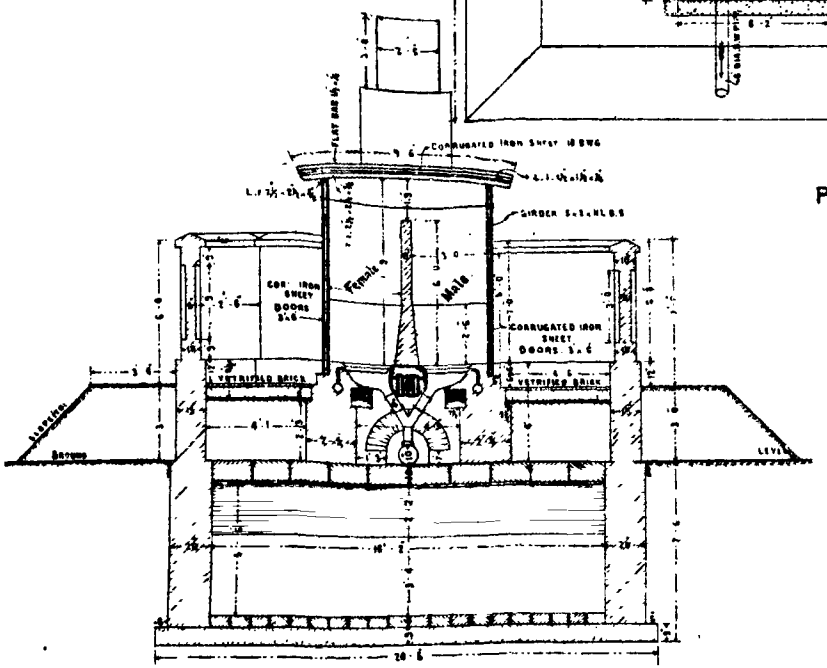
LATRINE WITH SELF CONTAINED LIQUEFYING TANK

Scale 4 Feet to an Inch.

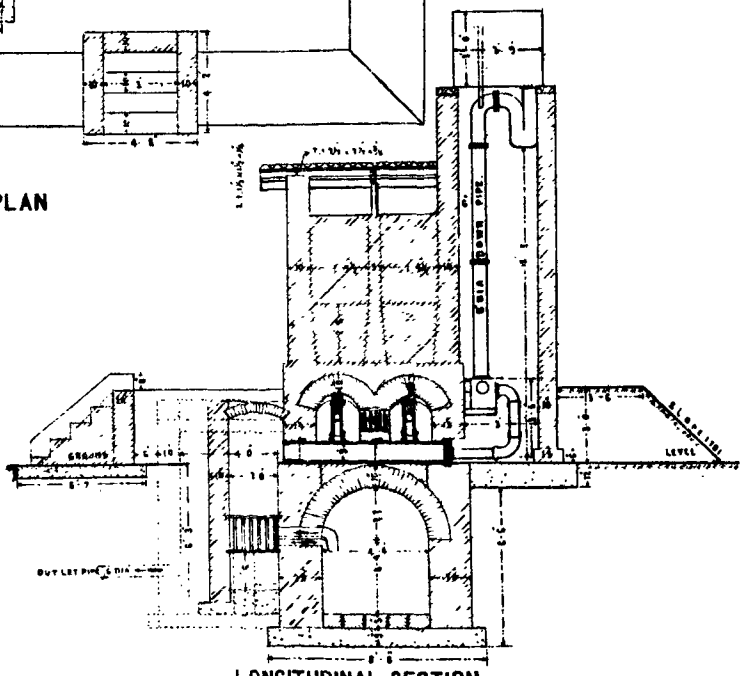
A.M.Inst:C.E.
Supervising Engineer.



PLAN



CROSS SECTION.



LONGITUDINAL SECTION.

No. 1. *Section Sanitary Road.*—This road which is known as Hewett Road begins at Station Road corner of Abbott Road and finishes on La Touche near Kasai Bara.

Kerb and channel drains connecting by means of gully pits to an underground drain have been laid along this road and pavements have also been provided.

Various houses have also gully pit connections for sullage, but as the underground drain unfortunately discharges into an open main drain, it has not been possible to use it as a sewer.

2nd Section.—This section which lies between Aminabad Park and Cloth Market connects the La Touche Road and Aminabad Road.

3rd Section.—The third section of Sanitary road commences at Aminabad Road and finishes at Canning Street on the R. and K. R. Bridge. A branch road leading to the various courts has been constructed at the end of the Aminud-daula Park which has been laid out on the northern side of this section. The metalling of this road is now complete, but pavements and drainage have not yet been commenced, as the houses are still under construction.

4th Section.—This section which commences at Canning Street, R. and K. R. Bridge, and finishes at Victoria Street near Nakhas, is now under construction, the earthwork being nearly complete.

Provision has been made for 30′ carriage way and 10′ pavements for these roads.

Boasganj.—Owing to large number of persons having been turned out by these improvements, it was necessary to provide some accommodation for them and a large area across the Gumti lying between the Normal School and Bengal and North-Western Railway has been laid out with broad unmetalled roads for this purpose.

Although the entire area available has not yet been occupied it has grown into quite a large village.

New Civil Lines.—The tract of land lying between the Gumti and Clyde Road, formerly known as Sultanganj, and then consisting of mango groves and the village of Sultanganj, has been cleaned and laid out in building sites of three and two bighas with frontages on broad roads.

For sanitary purposes narrow roads have been provided between every two rows of sites so that all refuse, etc., will be removed from the back of the premises.

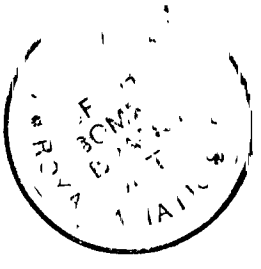
Some bungalows have already been built and occupied, and others are in course of construction.

From the foregoing short note of the improvements which have taken place in Lucknow during the last nine years, it will be seen that, although much has been done for the improvement of the city, there still remains far more to be done and until the present drainage scheme is supplemented by sewers and pipe lines enabling all those who can afford it to instal water carriage systems into their houses, the drainage cannot be looked on as satisfactory.

The provision of the new farm or farms for the treatment of sewage will do much to improve the present state of the river.

LIST OF PLATES.

1. Plan shewing areas already sewered and areas proposed to be sewered.
2. Plan shewing divisions of the main drainage scheme.
3. Typical House connection to sewer.
4. Typical House connection for sullage water.
5. Flushing Tank with Automatic Syphon.
6. Gully Pit shewing sewer connection.
7. Water Flushed Urinal.
8. Pail Depôts with Liquefying Tank.
9. Water Flushed Latrine.
10. Latrine with self-contained Liquefying Tank.



LUCKNOW WATER-WORKS.

BY

H. I. CARTER, A.M.I.M.E.,

Superintendent, Lucknow Water-works.

THESE water-works were opened for supplying filtered water to the City, Civil Lines and Cantonments on the 20th November 1894. The people before the opening of these works got their water from the river and wells ; after the works started a six-hour daily supply was given, since then the demand for water and hours of supply have gradually increased. At the present time there is a 16-hours filtered water supply from 5 A.M. to 9 P.M., the maximum supplied during the last hot season being 4,100,000 gallons per day of 16 hours and the average supply being 3,800,000 gallons.

There were four open sand-bed filters at the start, these have been increased by three of the same type.

At the installation of the distributions 36 miles of pipes from 3″ to 30″ were laid, now there are 65 miles.

There were originally 130 two-tap stand-posts and 90 one-tap for public use, there are now 227 two-tap and 170 one-tap stand-posts. Within the last four years the greatest increase has occurred, and 30 road watering posts have been erected, six large flushing tanks for the main sewer, several water flushed latrines and pail depôts for public and private use have been installed, also sanitary arrangements in hotels and private houses, all of which use the filtered water. There are now 3,275 house connections for domestic use and 368 metered connections for non-domestic use. The total population now is 2,59,000, including cantonments, there are areas which need piping and as soon as the unfiltered water supply can be supplemented (a scheme is now on for it) these areas will be supplied with filtered water. The total cost of these works up to date is about 19½ lakhs of rupees, the initial cost being 15¼ lakhs. A brief description of plant and process of purification follows. The intake at the unfiltered water pumping station is situated at Gau Ghat, Daulatganj, 6 miles up-stream from the weir, and above all the drainage outlets from the city, the unfiltered water is drawn from the River Gumti and pumped at the rate of 180,000 gallons per hour or 4¼ million gallons per 24 hours, through a 20″ main, of cast-iron 3¼ miles long, to the settling tanks at Aish Bagh distributing station. In the compound at Aish Bagh is a 20″ Venturi Meter which records by counter and diagram all the water passed. At Aish Bagh there are three settling tanks holding 2½ million gallons each, and for 15 years were filled and emptied alternately, latterly as the demand got over 3 millions per day of 15 hours' supply, it was found that the water had not time to settle sufficiently with the system of filling and emptying each tank alternately, so the three tanks were worked continuously, the unfiltered water coming in at one end of all three tanks which were kept full and delivering into the filters from the opposite end from all three tanks. This system has been found to give better results, the tanks have just been raised so as to hold 4 million gallons each, and so arranged as to flow from one tank into the second and out from the third into the filters; by this system a better result is expected. During the monsoons when the river water is full of sediment alumino-ferric is used and good results are obtained.

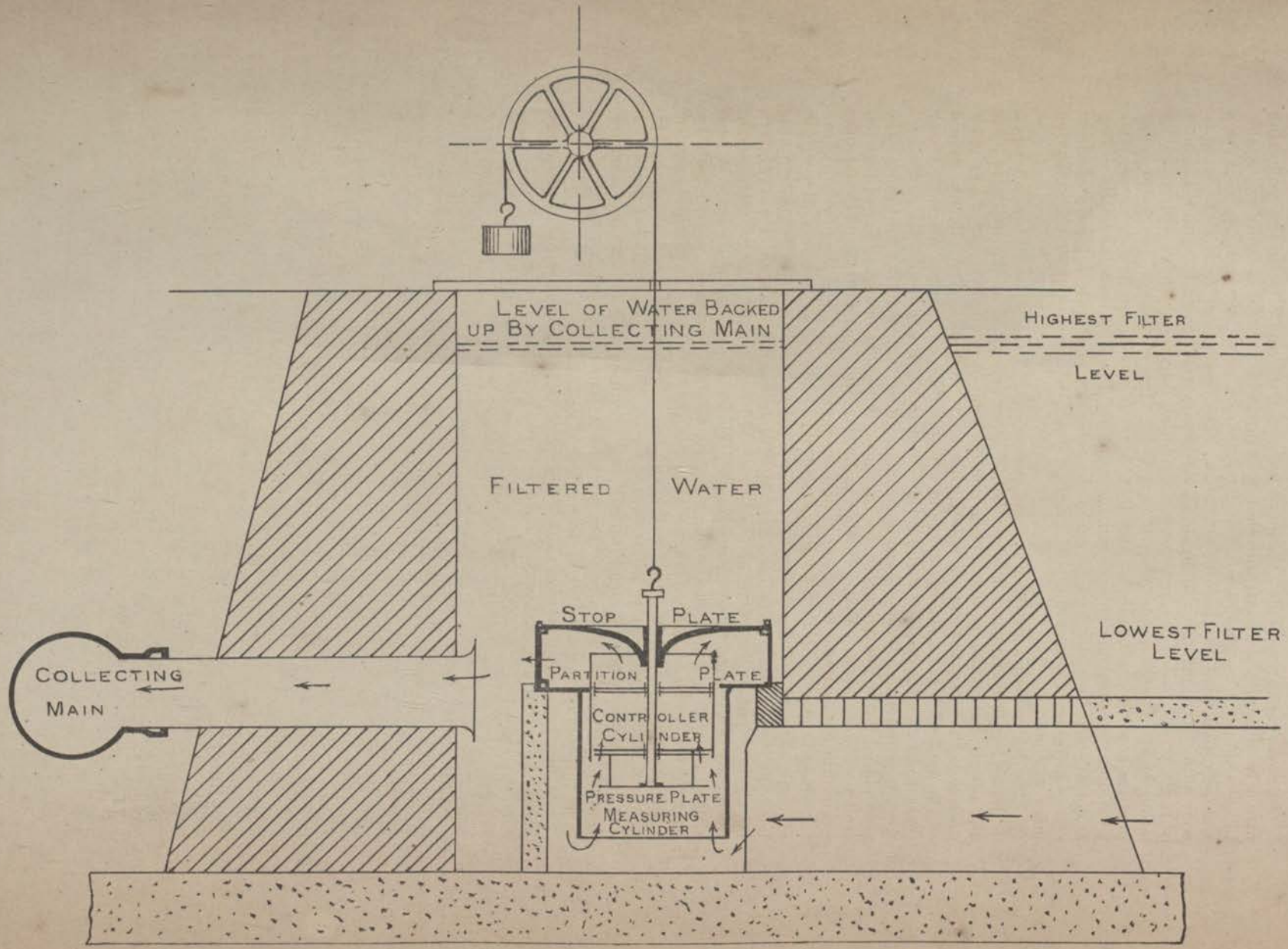
The filters are of the open sand-bed type, and flow into the collecting reservoir which supplies the distributing pumps, of which there are two sets, one of which works daily for 16 hours and the second assists for 8½ hours daily to maintain a pressure of 50 feet during the times of heavy demand ; these pumps discharge through a 30″ main in which is a Venturi tube with a counter and diagram to register the water going out.

Samples of the filtered water are taken regularly for bacteriological and chemical analyses.

There is a growing demand by all communities for filtered water in all parts of the town. As Lucknow is not a manufacturing town the supply is purely domestic, the average supply per head per day is about 12 gallons ; taking about

WILKINS FILTER BED CONTROLLER

SCALE ½ IN. = 1 FOOT.



$\frac{1}{5}$th of the population who cannot avail themselves of filtered water, the supply is reasonable.

A New Filter-bed Flow Controller.

A means of so controlling the outflow from slow sand filter to the collecting mains as to maintain a given uniform rate of flow which shall be readily adjustable to meet the requirements of different conditions of water and sand has long been a desideratum with water-works engineers. The instrument we wish to bring to your notice is the invention of Mr. C. F. Wilkins, a well-known Irrigation Engineer in India, who invented the instrument for another purpose entirely, namely, modulation of the flow through irrigation outlets. Its adaptation to water-works practice however constitutes an excellent means of flow control and is at the same time simple in construction and reliable and unfailing in its action. Its action is not affected by water backing up in the collecting main, which occurs when the rate of filtration is increased to a figure not contemplated in designing the collecting main system.

The instrument consists of a fixed measuring cylinder open to the filter-bed outlet underneath and partially closed at its upper end by an anular partition plate and a controller capable of free vertical motion. This controller consists of a cylinder open at both ends with a pressure plate attached to it below. The effective weight of the controller is varied by means of a counterbalance system above. A stop plate fixed at filter-bed low water-level complete the instrument. Its method of working is obvious. Water passing through forces the controller up towards the stop plate till it so constricts the discharging area round the upper edge of the controller cylinder as to prevent further upward motion, maintaining the controller in equilibrium between the pressure below the pressure plate and the pressure above the pressure plate, *plus* the effective weight of the controller. The effective weight of the controller therefore expressed as a head of water constitutes the working head on the discharging orifice. The discharge is thus constant for any given effective weight of controller and can be altered by changing the effective weight by means of the counterbalance weights. Thus no increase or decrease of head either in the filter or in the collecting main can alter the discharge, provided always that the collecting main head is lower than the filter head by an amount equivalent to or greater than the effective weight of the controller expressed as head. This amount may be reduced to any figure desired. In the controller installed at Lucknow Water Works it varies from $3\frac{1}{4}''$ to $\frac{3}{8}''$, being capable of a range of discharge from 75 to 25 gallons per square foot per twenty-four hours and any range of filter level possible from low water up to ten feet if necessary.

A flow measurement weir and recorder are fitted when required to show on a chart the actual discharge at all times.

FURTHER INVESTIGATIONS INTO THE PERSISTENCE OF PLAGUE INFECTION IN THE VILLAGES OF POONA DISTRICT DURING THE OFF-SEASON.

BY

CAPTAIN J. C. G. KUNHARDT, I.M.S.,

Member, Plague Research Commission.

IN a paper entitled "The Importance of the Persistence of Infection in certain Villages during the Off-plague Season,"* read before the All-India Sanitary Conference held in Madras in November 1912, an attempt was made to study the behaviour of plague epidemics during the off-season in Poona district. We will briefly recapitulate the method employed in the investigation.

In searching for material to study it was found impossible to define exactly in which of the infected villages† mentioned in the Plague Progress Reports of the Government of Bombay the disease persisted during the off-season. All villages were therefore noted which returned human cases or deaths during any of the first three months of the plague season, *viz.* : July, August and September, as well as in any of the six months which precede that period, and it was tentatively assumed that these villages would include most of those that carried plague infection over the off-season period, *viz.*, April, May and June in each of the various years.

The monthly totals of plague cases and deaths in the villages which came under this category were then entered on a "chart"‡ which thus furnished a more or less graphic record of the plague histories of these places.

By a more detailed study of the course of plague in each of these villages, bearing in mind certain limitations to this method of investigation, they could be further grouped approximately into those which almost certainly carried plague over each off-season and those in which evidence of this was doubtful or obscure.

The behaviour in regard to plague epidemics, and the geographical and other peculiarities of the villages which "carried over" were then studied, and certain conclusions were arrived at as to the persistence of plague infection during the off-season in the villages of this part of India.

These conclusions were however based on the behaviour of the comparatively small number of villages which happen to come into the above category, and also based on the hypothesis that these villages would include *most* of those that carried plague infection over an off-season period.

Moreover, these villages, on the examination of which the deductions were based, would naturally be limited to those in which infection took place fairly late in the plague season; also to those in which there happened to be a comparatively short plague-free interval between two successive plague seasons, and which in consequence returned plague cases, in the second season, before the end of September. It was regarded at the time as possible that some additional villages might be found in these plague records of Bombay Presidency, which, infected early in the previous plague season, may have returned no human plague during the period January to June preceding the second plague season. Others may have returned no human plague during the first three months, July to September, of the second season, yet they may nevertheless have remained infected in the off-season period, April to June. These villages would not be found amongst those mentioned in that paper, and so would have failed to come under our observation.

If villages such as these were to be found in Poona District, it would greatly obscure the issue, for it would then be more difficult to discriminate between those which probably carried plague over an off-season and those which may have become re-infected during the second year from neighbouring places already infected by that time. Our deductions would have to be modified, and it would materially diminish the utility of this work from a prophylactic standpoint, for the proportion of villages which would be necessary to keep under observation as likely to carry plague over any off-season would be considerably increased.

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* *Vide* Proc. Second All-India Sanitary Confce., Vol. III (1912).

† For convenience the term "village" is frequently used in this paper to include also towns and cities as units of infection.

‡ Square ruled chart paper with eight squares to the inch can conveniently be used for this purpose.

The above-mentioned paper, based on the behaviour of a limited number of selected villages, was therefore not complete, and in order to confirm or refute two important deductions made in it, it was decided to make a further investigation of the records contained in the Plague Progress Reports of the Government of Bombay and to examine the subsequent history of *all* villages infected during any two years. The deductions in question were :—

(*i*) Whenever villages are infected early in the plague season, infection dies out completely either before or when the following off-season is reached.

(*ii*) When infection is implanted late, however, it occasionally continues over the following off-season.

Our main object in this work was to trace the subsequent plague history of all villages infected (*a*) early, and (*b*) late in any plague season. Besides endeavouring to throw further light on the general behaviour of plague epidemics in the villages of a district, we endeavoured to ascertain if there were any evidence of plague being carried over an off-season by villages infected early in the plague season, and also if there were any evidence of villages, which may have carried plague over an off-season, not showing signs of epidemic plague till somewhat late in the following season, *i.e.*, after the month of September.

The following method of investigation was adopted :—Only villages with a population of over 300 were considered. All such villages in which an epidemic commenced early, that is, within the first six months (July to December 1902) of the plague season of 1902-03, were taken and their plague cases and deaths, which occurred in each month, were entered on a chart, similar to the charts already described in the previous paper. Their plague statistical history was then traced in the same way for the remaining three months of that plague season, through the off-season of 1903, and finally throughout the whole of the plague season of 1903-1904. The result of this is shown on Chart No. I.

In the same way, the subsequent plague history of the villages infected early (July to Decemeber 1903) in the plague season 1903-04, was traced to the end of the plague season 1904-05, and this is shown on Chart No. II.

Then, again, all villages were taken which were infected late (January to June 1903), in the plague season of 1902-03, and their subsequent plague history was traced to the end of the plague season 1903-04. The result of this is shown on Chart No. III.

Finally, all villages were taken which were infected late (January to June 1904), in the plague season 1903-04 and their subsequent plague history was traced to the end of the plague season of 1904-05. The result of this is shown on Chart No. IV.

We will now examine these charts in detail :—

Chart No. I.—It will be seen that amongst the 53 villages in which epidemics commenced in the period July to December 1902, *i.e.*, early in the plague season of 1902-03, forty-three showed no plague cases or deaths whatever during the plague season of 1903-04. In these forty-three villages we may assume, therefore, that plague infection died out completely either before or when the following off-season was reached. The question then arises: Are all or any of the remaining ten villages, infected in the subsequent season, exceptions to the rule, or does their situation render them particularly liable to re-infection during the second plague season ?

A reference to the map of Poona district will at once elicit the striking fact that of these ten places no less than eight, *viz.*, Lonavla, Valvan, Poona, Kirkee, Khadkala, Khandala, Talegaon and Chinchwad, are situated on the railway and main road to Bombay. Of the remaining two, Alandi (Khed) is one of the most important places of pilgrimage in the Deccan, and Parbatti is contiguous to Poona City in which an epidemic of considerable severity was already in progress at that time.

Evidence in the case of these ten places, therefore, points to re-importation of infection. A few special remarks are however necessary in the case of three places mentioned in this chart, which, of all the above ten, are the most likely to have bridged the off-season, *viz.*, Kirkee, Poona and Talegaon. Of the other seven, none had a plague-free interval of less than seven months (*see* chart).

1. *Kirkee Cantonment* is a suburb of Poona, 8 cases and 6 deaths occurred here in September and October 1902. An epidemic had just commenced in Poona City (*see* chart); it is possible that these cases were refugees from the latter and not local cases. If this were so, then Kirkee itself was not infected till January 1903, *i.e.*, *late* and not early in the plague season, and in consequence carried infection over the off-season of 1903. This resulted in an early and severe epidemic in the following plague season. There appears to be no adequate reason, then, why we should regard Kirkee as an exception to the deductions mentioned above.

2. *Poona City.*—In the paper read before the Sanitary Conference, already referred to, it was pointed out that Poona City might sometimes be a real excep-

tion to the deductions mentioned. Owing to its size, the rat population is more slowly exhausted by the epizootic (*see* chart), and though this may commence early, it may not have time to diminish their number sufficiently to cause the disease to die out by the time the following off-season is reached. In spite of an early infection, it may, owing to its size, carry plague over the subsequent off-season.

In the same paper it was also mentioned that Poona might at times be an apparent exception to the deductions mentioned. After an early infection plague may die out completely before the following off-season is reached, but owing to its extensive trade communication, Poona is likely to become re-infected by importation early the following plague season. In spite of an early infection in the first season it may therefore sometimes appear to carry plague over an off-season when in reality it was re-infected during the second season by a fresh importation. Considering now what we have just said in regard to the epidemic in Kirkee, that the Kirkee epidemic was already at its height when that of Poona commenced, and that no cases or deaths were reported in Poona for four consecutive months, it seems quite reasonable to assume that in this year Poona, in spite of its more prolonged epidemics, did not carry plague over the off-season, but was re-infected from Kirkee.

3. *Talegaon* remains to be considered. It may possibly be that in spite of an epidemic commencing here as early as October, plague infection carried over the subsequent off-season. Its geographical position is however all in favour of re-importation. It is a village of considerable size and importance, situated on the railway, near the main road between Poona and Bombay; and Kirkee, a suburb of Poona, was then already infected. Moreover, at Talegaon, the main Poona-Bombay road is joined by a road which brings a considerable amount of grain and other produce from the north of Poona district and portions of Ahmednagar district. (The latter district was at the time extensively infected.) From Talegaon this produce is conveyed to Bombay by rail. A detailed examination of these three places which are apparent exceptions, is therefore very instructive.

Chart. No. II.—An examination of this chart shows that in 63 villages plague commenced during the first six months of the plague season of 1903-1904, *i.e.*, in the period of July to December 1. Of 903, these 63 villages, 46 returned no cases or deaths during the subsequent plague season (1904-05). In two others, Pimple-Saudagar and Warwand, less than three cases occurred during the second plague season so that these may be regarded as imported and not local cases. We may, therefore, say that in 48 out of the 63 villages infection undoubtedly died out at the end of the first plague season.

Of the remaining 15, four are situated on the railway and on the main road and 6 are either contiguous to, or part of Poona City where a severe epidemic was raging at the time.

Five now remain to be considered and of these, three, *viz.*, Mekhali, Undawadi and Tundalwadi, are situated neither near Poona City nor are they on any main road or railway leading thereto. Can it be possible that in these three villages plague infection was carried over the off-seasson of 1904, in spite of their epidemics commencing early in the previous season (*see* chart), and in spite of there being an interval of apparent freedom from plague of 9, 15 and 10 months, respectively, between their two successive epidemics?

An examination of the records and map, however, reveals the fact that Mekhali and Tundalwadi are situated only seven and two and a half miles, respectively, from the large and important village of Baramatti in which a severe epidemic was already in progress. Undawadi is situated 10 miles from Baramatti but only from five to seven miles from Sirsupal, Bharampur and Karahati, in all of which an epidemic of plague had already commenced. It is probable, therefore, that in 61 out of the 63 villages plague infection died out completely at the end of the first epidemic.

Only two of the sixty-three places now remain to be considered, *viz.*, Poona City and Bavda. In the case of Poona City there can be little doubt that plague infection bridged the off-season, it was thus in this year a real exception to the rule; an explanation for its exceptional behaviour has already been put forward. In the case of Bavda, it is possible that this village may have carried plague over the off-season in spite of being infected as comparatively early in the plague season as December. It is however not a very large village, and as it is only nine miles from Niemgaon-Ketki, in the same taluq, which undoubtedly did carry plague over the off-season, it is perhaps more likely that, even in this case, plague died out during the following off-season and was re-introduced during the second plague season.

An examination of this chart therefore shows that, with the exception of Poona, in all places infected early in the plague season of 1903-04, infection probably died out at the end of the season, and they would therefore conform to the rules already referred to.

Chart No. III.—All villages were now taken in which plague epidemics commenced late in the plague season of 1902-03, that is, in the period from January to June 1903. They number 76, and of these, 54 show no infection during the second year;—if we may consider that less than three cases in a village during the second plague season indicate imported and not indigenous cases.

Of the 22 villages that remain there is little doubt that in Kirkee, Narayengaon, Undawadi and Mekhali and possibly also in Katfal and Malthan*, plague having commenced late in the season was successfully carried over the subsequent off-season.

Amongst the 16 that now remain, it is of course possible that in a few infection may have been carried over the off-season, but in all of these the interval of apparent freedom from plague ranged from 6 to 11 months, and in all of these strong evidence can be found for their re-infection, during the second season, by importation from other infected places in their neighbourhood; for of these 16 villages, 9 are either adjacent to Poona, or are in the same taluq (Haveli) which by that time had already become extensively infected. Three other are on the railway and four are situated in the taluqs Mawal, Junnar and Bhimtadi, in which taluqs several adjacent villages were already infected at the time. (For details *see* Chart No. III).

It may, therefore, be assumed that all these 16 remaining villages derived their infection in the second plague year by importation.

Chart No. IV.—Forty-three villages are found in this chart, of these 33 showed no signs of plague infection the following season. Of the ten remaining, four are either part of, or contiguous to, Poona City; one is on the main road and railway between Bombay and Poona; another, Bharampur, was probably re-infected in November 1905, from one of the many villages in the same taluq (Bhimtadi) already infected, and only four, Niemgaon-Ketki, Hadapsar, Mandavgaon and Sansar† either wholly or partially bridged the off-season.

The information obtained from these four charts has been summarised in Table No. I.

TABLE No. I.

Table showing the number of villages of Poona District infected early and late in the plague seasons of 1902-3 *and* 1903-4 *and their probable source of infection in the following plague seasons.*

No. of Chart.	When infected.	VILLAGES NOT INFECTED, 2ND SEASON.		VILLAGES INFECTED, 2ND SEASON.					Total No. of villages.	REMARKS.
				INFECTION PROBABLY IMPORTED.				INFECTION NOT IMPORTED.		
		No cases or deaths 2nd season.	Less than 3 cases, 2nd season (not indigenous).	On line of ry. and main rd.	Place of pilgrimage.	Part of Poona or in same taluq (already infected).	Other villages in same taluq already infected.	Carried over off-season.		
I	Early Epidemic.	43	..	7	1	1	..	1 (1)	53	(1) *Kirkee.*—First 8 cases probably imported from Poona. Epidemic probably did not commence till January, *i.e.*, *late* epidemic.
II	Early Epidemic.	46	2	4	..	6	4	1 (2)	63	(2) *Poona.*—Carried over in spite of an early epidemic.
III	Late Epidemic.	49	5	3	..	9	4	6 (3)	76	(3) Even in these Katfal and Malthan may have been re-infected from Undawadi and Mekhali.
IV	Late Epidemic.	33	...	1	..	4	1	4 (4)	43	(4) Even in these Sansar's first 7 cases may have been imported from Niemgaon-Ketki and Sansar subsequently infected from Baramatti (9 m.).
TOTAL ..		171	7	15	1	20	9	12	235	
		178		45				12	235	
		Infection not carried over—223.						Inf. carried over—12	235	

**Note.*—Even Katfal and Malthan may possibly have been re-infected from Undawadi and Mekhali in the same taluq, and not far distant (*see* Chart No. III).

† *Note.*—Even in Sansar, the original seven cases may have been imported from Niemgaon-Ketki, 15 miles distant, and the former may have been subsequently infected from Baramatti, 9 miles distant

From this table it will be seen that amongst all the 235 places mentioned on these charts, in 178 or 75·7% there was no epidemic in the second plague season and in another 45 in which an epidemic during the second season occurred, strong evidence pointed to re-importation, and not persistence of infection, as the cause of the epidemic. For of the forty-five villages, fifteen are situated on the railway or main road, one is a noted place of pilgrimage, and twenty are either part of Poona itself, or situated not far from it, in the same taluq (Haveli). These twenty all acquired their infection at a time when there was an epidemic in Poona or when many other villages in Haveli taluq were already infected. Nine other villages are situated in various taluqs which were already more or less severely infected at the time when their own epidemics commenced.

But even if we admit that in these 45 villages evidence points strongly to re-importation of infection as the origin of the epidemic in the second plague year, we still cannot deny the possibility that, in the case of some of these villages, plague infection might in reality have been carried over the intervening off-season in the form of acute plague amongst the rats, though human cases were not returned.

Now it is clear that proximity to a focus of infection, or situation on a line of railway, though influencing the chances of importation, can in no way influence the facility with which infection is carried over the off-season.

Excluding the 12 villages in which evidence suggested that plague infection was carried over the off-season, we have seen that amongst the 45 in which plague epidemics occurred during the following plague season, 44 are situated either on the railway line or near one or more places already infected earlier in that season, and the only one which is not so situated, namely, Alandi, is one of the most important places of pilgrimage in this part of India. If plague infection had bridged the off-season in any of these, one would expect it also to persist during the off-season in some of the villages not so placed, and yet in 178 villages most of which were more or less remotely situated in the district, no plague epidemic occurred during the second season (*see* table).

We may take it then, that in at least 223 out of 235 villages, or 94·9%, plague infection died out completely at the termination of the first epidemic.

In the remaining twelve*, or 5·1% of the total, plague infection appears to have been carried over the off-season. Of these, 11 had epidemics which commenced late, that is, either during or after the month of January (Kirkee being the only doubtful one), and in only one place which bridged the off-season, *viz.*, Poona, did a plague epidemic definitely commence as early in the plague season as the month of September.

Before concluding this paper, it would be advisable to draw special attention to the following points:—

(*i*) It might be argued that a severe epizootic of plague in any given place would reduce the rat population to such an extent that an epidemic amongst human beings might not make itself manifest again till late in following season although infection among the rats would be present all the time. If this were the case, then more villages might carry plague over the off-season than at first appear to do so. Against this however is the fact that, when a village is apparently re-infected quite early during the second year by importation of infection an epidemic of considerable severity may nevertheless ensue.

(*ii*) It must be clearly borne in mind that remarks made in the present paper and any deductions that may be made from this work, apply to villages of Poona district. We have no reason to suppose that this district differs greatly from the majority of districts of India, but there can be little doubt that in some parts of India, and possibly in other parts of the world, plague infection is carried over the off-season with much greater facility than it is in Poona district.† On the other hand, there might possibly be other places where conditions, climatic or otherwise, make it almost impossible for infection to survive the off-season.

(*iii*) In some parts of India there is comparatively little plague; it does not follow that this necessarily depends, to any great degree, on the extent to which plague is carried over the off-season. In some

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* *Note.*—Including Katfal, Malthan and Sansar. If these doubtful ones were excluded, the figures would be reduced to nine, or 3·8%.

† *Note.*—This is probably due to two chief causes:—(i) When off-season conditions are never very unfavourable for plague, and (ii) when a large proportion of the villages of a district are infected late in the plague season. For instance, in portions of the Punjab and the United Provinces conditions are apparently more favourable for the disease in the later months of the plague season. In these districts a larger proportion of village are infected late in the season and a larger proportion would therefore carry over plague infection than in Poona district where factors favouring the disease are more pronounced in the earlier than in the later months of the season.

districts of the Madras Presidency, for instance, and especially on the West Coast where seasonal conditions, climatic or otherwise, are never very favourable nor yet very unfavourable for plague, comparatively few villages may be infected in the plague season, yet the disease appears to have little difficulty in surviving the quiescent period and a considerable proportion of villages carry over plague infection.

(*iv*) It must be remembered too that these observations were made in more or less normal years, it is probable that under abnormal conditions plague would survive the off-season with much greater or less facility.

(*v*) The larger the town, the more is plague likely to survive the off-season in it. The behaviour of a large town like Poona resembles in this respect a group of small villages. Various portions become infected in turn. Immediately before the off-season some highly rat-infested portion perhaps becomes infected for the first time during that epidemic, and in consequence there is little difficulty in the disease surviving the off-season in that locality.

(*vi*) It is probable that some villages may become infected just before or actually during the off-season. The presence of infection may not manifest itself in the form of human cases, till the subsequent plague season and so would not come under our notice in these charts. This however is not likely to occur very frequently* for during the hot and dry weather of the off-season, the number of fleas is very small, and moreover the length of life of a flea under those atmospheric conditions is very limited. It is probable that, chiefly for the latter reason, plague infection can spread from rat to rat in a town with much greater facility, than from town to town in a district during the off-season.

(*vii*) Table I throws some light on the limits to which plague infection can usually be conveyed and the importance of railways in the diffusion of the disease. Out of 178 villages, most of which are more or less remotely situated, none were infected during the second season, whereas amongst 45 into which infection was re-imported during the second year, 15 or 33% are situated on the railway and 29 (of which 20 are either directly or indirectly associated with Poona City), were probably infected from places only a few miles distant from them.

(*viii*) It must always be remembered that the figures in the Plague Progress Reports which we have analysed in this paper are very far from perfect. They are, however, so large that, by taking a broad view of facts, we do not think any errors that may have been made in their collection would materially affect the main deductions that we have arrived at. It must also be borne in mind that the figures referred to in these charts are those of human cases and deaths; it is assumed that, on broad lines, these may be taken, for our purpose, as an approximate index to the co-existing epizootic.

Finally, I should like to draw attention to the method I have devised for studying the history or behaviour of plague in the villages of a district, by means of the "charts" which have already been described. It is at once a simple, convenient and complete statistical, as well as a more or less graphic, record of the plague history of such places. By this method we can conveniently study the behaviour of all villages, or of any particular group of them, during any number of years for which the returns are available, bearing in mind, always, the various sources of error to which such statistics are open. By this graphic record we can see at a glance† which villages have probably carried plague over previous off-seasons and which have not, and we can compare the proportion of villages which carry over plague in various districts or in different years. We could also study the meteorological and other conditions prevailing in particular districts, or in years when a large proportion of villages carry plague over and compare them with conditions prevailing in other districts, or in years when it was apparently carried over with some difficulty.

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* *Note.*—It is probable that in many parts of India this occurs more frequently than it does in Poona district.

† *Note.*—Especially in a district like that of Poona, where the off-season is of fairly short duration and where there is a marked contrast between the unfavourable conditions of the off-season and the favourable conditions during the earlier months of the plague-season. On the other hand, in districts where there is a mere gradual transition between favourable and unfavourable conditions, and especially in districts, when a large proportion of villages become infected every year, it would be more difficult to distinguish between those villages which apparently carried plague over the off-season and those which were re-infected during the second season by importation from other places already infected.

Experience thus gained of the behaviour of plague in any particular district or area during previous years would greatly assist us in future in locating the villages, amongst those infected late in the season, which are likely to carry plague over the following off-season in that district. In many cases these villages will be found to comprise a very small proportion of the total number of villages in a large and populous area, and it might well be considered worth while to endeavour to prevent plague from carrying over in these few suspected villages by a small reduction in their rat population during this off-season, in addition to that reduction already produced by the prevailing epizootic of plague.

We have seen in this and in the previous paper to what a limited extent plague infection is transported in this part of India, from one place to a more or less distant one ; so having once rendered the district plague-free, it is possible that, at any rate where conditions are similar to those of Poona, infection may not again be introduced from outside for some time afterwards.

This method of recording plague could also be adapted to large towns, when these are divided up into a number of different wards. The record of the cases and deaths in each ward can be kept in a manner similar to that of villages. After a number of years we would be able to determine in which wards plague is more likely to be handed over in the off-season, and which are usually free from infection during that period. This would greatly facilitate prophylactic measures, when undertaken with a view of stamping the disease out of the town.

Summary and Conclusions.

The following conclusions may be made regarding the villages of Poona district :—

I. Almost all plague epidemics in villages are strictly limited to one plague season. Rare instances where epidemics overlap two seasons occur occasionally only amongst those villages infected late in the plague season.

II. In no instance does a village, in which a plague epidemic is terminated by the month of December, nor indeed *commenced* before the month of January, shew plague cases again, early the following season, which cannot be explained by evidence of re-importation.

III. Poona City is an exception to the first two conclusions. The larger a town the more prolonged are its epidemics (*see* charts). A large town such as Poona may therefore become infected early in the plague season and would nevertheless be able to maintain an epizootic during the following off-season.

IV. In no instance does plague recur during the second plague season, after the month of September, in which evidence, such as geographical position, favouring re-importation cannot amply explain the presence of infection.

V. All places which show plague cases in the first three months of the plague season, as well as in any of the previous six months, would, under normal conditions, include most of those that carry plague infection over the intervening off-season; the few exceptions being those places which, infected either immediately previous to or during the off-season, do not for various reasons, return human cases or deaths till the following plague season had commenced.

The above conclusions are supported by the fact that, practically all villages shown in the four charts which are more or less remotely situated in the district, and into which there is consequently little chance of re-importation of infection, remained free from the disease during the second season ; and that in practically all villages shown on the four charts whose geographical situation renders them specially liable to frequent importation of infection, either by means of the railway or from neighbouring infected places, epidemics of plague, or at any rate a number of plague cases occurred during the second plague season.

CHART No. I.—Subsequent Plague History of all villages of Poona District (population over 300) in which epidemics commenced *early* (July-December 1902) in Plague Season, 1902-1903.

	Pop.	Place	Taluq	1902 July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	1903 April.	May.	June.	1904 July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	April.	May.	June.	Remarks relative to source of infection in second season.
													Off Season.															
				14	82	95	44	2			4								6	23	26	10					
1	3856	Lonavla	Mawal	8	50	73	42	3			3								3	18	27	7						On railway and main road, Poona-Bombay.
				22	94	110	182	26	29	5	1	1															
2	6382	Otur	Junnar	11	68	145	170	46	25	1	2	1															
				13	90	298	64	7			11	38	1														
3	4279	Charoli	Haveli	7	32	228	51	8			9	19	7														
					135	58	3																				
4	1088	Khalad	Purandhar							4																	
					93	55	5																				
5	569	Ambe	Do.		72	74	5																				
					19	36	6																				
6		Dingore	Junnar		14	130	36																				
					7	130	32																				
7		Punawale	Haveli		13	64	15	2																			
					8	42	16	3																			
8	492	Kumbharvalan	Purandhar		36	78	6	0																			
					23	17	11	1																			
9	919	Valvan	Mawal			38	19															3					
						23	15															1					On railway and main road, near Lonavla. Probably in portiel cases and no local epidemic.
10	693	Korkamb	Bhimtadi			13	54	6																			
						11	23	3																			
11	444	Wanapuri	Purandhar			84	49	2	0																		
						40	40	0	0																		
12	325	Khanwali	Do.			44	28	5	3																		
						25	30	3	3																		
13	3380	Rajuri	Junnar			55	174	65	17																		
						69	136	56	18																		
14	497	Ekthapur	Purandhar			7	23	11	16	4																	
						4	6	9	11	4																	
15	6124	Saswad	Do.			36	210	178	68	5	5																
						73	155	174	69	6	8																
16	132939	Poona City and Suburbs	Haveli			21	23	168	797	2821	3236	825	39					3	261	881	720	871	606	321	38	4	1
						10	32	121	712	2476	2825	630	26					1	137	508	644	782	514	294	36	1	0
17	3040	Kirkee Cantonment	Do.			1	1			22	51	11				12	10	160	96	92	1	1					
						6	0			19	45	12				7	11	92	60	31	1	1					On railway and main road, near Poona. Rats probably not infected till January and then carried over.
18	3082	Gunjalwadi	Junnar				26	5																			
							26	4																			
19	373	Charoli	Khed				6	6																			
							14	11														1		14	4	0	
20	833	Khadkala	Mawal				13	14														1		12	4	1	On railway and main road, Poona-Bombay.
21	416	Nigde	Do.				6		6																		
22	392	Dhamne	Do.				5	15	7																		
23	2392	Khandala	Do.				1	4	4													4	2	12	6		
							1	10	3																		
24	9655	Junnar	Junnar				1	7	6													4	0	13	2		Ditto ditto.
							7	116	314	73	6																
25	894	Sole	Khed				8	31	8		1																
							9	18	3		1																
26	1406	Hiwre Bk.	Junnar				14	9	30	12	0																
							9	8	17	17	1																
27	3218	Talegaon	Mawal				44	34	31	21	24	6					3	32	39	31	8						On railway and near main road, Poona-Bombay
							6	5	22	28	99	42					3	28	23	281	9						
28	6328	Ale	Junnar				5	5	9	27	85	98															
29	9407	Baramati	Bhimtadi				7	186	349	71	20	4															
							3	154	263	3	18	1															
30	2010	Alandi	Khed				1	6	18	36	20	9								6	0	27	14	1			Important place of pilgrimage.
							1	2	16	9	17	0								3	6	19	11	1			
31	1090	Dhalwat	Junnar				0	50	5	2		0	7														
32	396	Bhaje	Mawal				8	30	6	9		4	1														
								4	2																		
33	401	Walunj	Purandhar					1	2																		
								12	4	12	17	9															
34	1167	Nirgudsar	Khed					9	3	6	20	3															
								30	11	2																	
35	858	Pimple	Purandhar					23	7	4																	
								13	15	7																	
36	1018	Pargaon	Do.					13	17	3																	
								22	68	32	16																
37	2308	Dive	Do.					7	30	23	6																
								6	58	48	53	22	2														
38	3077	Sopa	Bhimtadi					4	44	31	27	9	4														
								4	0	4	34	31	1														
39	1950	Mahalunga	Khed					2	1	4	26	13	1														
									50	0																	
40	1200	Chincholi	Do.						41	7																	
									22	35																	
41	601	Bhiwadi	Purandhar						17	23																	
									15	10																	
42	598	Ambegaon Bk.	Haveli						7	7																	
									8	5	3																
43	1708	Savargaon	Junnar						4	4	2																
									118	19	1																
44	905	Hivre	Purandhar						69	7	63	17															
									1	1																	
45	1042	Chinchwad	Haveli						2	36	21																
											6																
									1	5										1	1	12	4				On railway near main road, Poona-Bombay, minor place of pilgrimage.
46	1412	Morhi	Do.						0	4	4	3								1	1	8	3				
									7	1	3	2															
47	974	Shewi	Purandhar						27	23	16	3															
									26	22	23	3															
48	450	Kolwihir	Do.						71	7	6	3															
									13	23		2															
49	581	Anjangaon	Bhimtadi						9	21		1															
						1			1	12	20	18															
50	1312	Dhayari	Haveli			1			1	6	13	17															
									84	64	16	3															
51	2821	Gunaadi	Bhimtadi						64	31	21	3															
									6	26	11	6															
52	1161	Malad	Do.						2	14	10	4															
									2	11	25	10															
53	479	Parbatti	Haveli						7	6	22	0								2		3					Contiguous to Poona City.
																				2		3					

CHART No. II.—Subsequent Plague History of all villages of Poona District (population over 500) in which epidemics commenced early (July-December) in Plague Season, 1903-1904.

	Pop.	Place.	Taluq.	1903										1904										1905						Remarks relative to source of infection or spread thereof.
				July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May	June.				
														100 Deaths.																
1	3000	Kirkee Cantt.	Haveli	22	10	108	66	42	4	1											11	17	3							
2	2000	Manjhar	Khed	7	11	81	60	24	1												8	15	4							On railway and main road near Poona (infected).
3	1000	Mahlali	Shirdahi	10	8	213	218	31	1	1																				
				8	23	70	120	67	1																					
					13	9	6	2																						
4	1041	Mahlali	Shirdahi		14	3	3	1												1	20	4								Seven miles from Baramatti, severely infected in September and October 1903.
					33	35	8													5	11	4								
5	625	Undawadi	Do.		36	17	11																					9		5 to 7 miles from Shirapal, Bhavanpur, Karhati (all infected), and 10 miles from Baramatti, epidemic just over.
					6					7	13	47	34															4		
6	710	Malthan	Do.																											
					7	7	27	29	31	6		3	9	13	14															
7	5250	Talegaon Dhabade	Maval		3																		7							On railway and main road, Bombay-Poona.
						9	73	78	8														6							
8	13230	Poona City and Suburbs	Haveli				1	157	308	644	782	554	198		38	4	1	14	13	30	903	1629	1091	826	225	112				Probably carried over plague, owing to large size and more prolonged epidemics.
							37	4							36	1	0	5	11	71	854	1332	1046	741	226	98				
9	655	Undri	Do.					14	8																					
								9	4																					
10	1233	Dapodi	Do.					6	36	11																				
								5	8																					
11	573	Mulhali	Shirawli					9	2																					
								7	4																					
12	681	Katykal	Do.					4	104	10	1																			
								1	12	8	6																			
13	513	Kuje	Maval					15																						
								23																						
14	1061	Pirth	Do.					13	125	41	1																			
								4	41	40	2																			
15	3045	Narayangaon	Junnar					36	45	23	17	27	7																	
								17		23	17	10	10	6																
16	1452	Kanher	Sirur					14		1																				
								9	2																					
17	7232	Ghodnadi	Do.					9	45	126	37		2																	
18	415	Pimpalgaon	Haveli						7	26	103	13	1																	
										36	7																			
19	580	Pimple Saudagar	Do.							13	3																			
										9	17	12											2							Cases probably imported and no epizootic amongst rats.
20	1252	Nimbut	Shirdahi							4	11	10											2							
										35	39																			
21	1195	Patas	Do.							21	79																			
										3		11	30	23	8															
22	618	Tandulwadi	Do.							61	4	9	13	11	5															
																				6	75	18								7½ miles from Baramatti, severely infected in September and October 1903.
23	1052	Shirdahi	Do.							23	11									4	30	12								
										22																				
24	1070	Mahalunge	Khed							28																				
										6	25	38	31																	
25	1606	Lonavla	Maval							2	15	27	7		1								1	11	11					On railway and main road, Poona Bombay (former infected—see above).
										9	6												1	9	11					
26	2045	Sirur	Sirur							3	17	8			9															
										4																				
27	1009	Ranjangaon	Do.							7	35	25	5																	
										21	18	2																		
28	1031	Palasdev	Indapur							11	35	19	43	10	4															
										7	25	47	24	11	2															
29	5333	Indapur	Do.							53	125	209	58	15	2															
										7	141	109	35	15	3															
30	7206	Parbatha	Purandhar							2																				
											16		1										3	2	1					
31	981	Wanawri	Haveli								10		1										5	8	1					Part of Poona Cantonment (Poona City infected—see above).
											30	3																		
32	1143	Bopkhel	Do.								29	1																		
											4	2	15	3																
33	1141	Alandi Chorachi	Do.								4	2	15	3						14										One Mahrat and 6 Mahratta Sailway, Poona-Belgaum (Poona infected—see above).
																				13			3							
34	750	Khandhara Kd.	Do.																		11	2								
											1	4	4								10	1								7½ miles from Poona (infected).
35	4321	Handiwa	Do.								3	6	13									2	5						4	
											1	5	5									1							1	
36	922	Parwati	Do.								2	1	1									4	1	7	6				4	Near Poona and Hadapsar, cotton mills (Poona infected—see above).
											2	3	8									8	8	7	2	2			2	Contiguous to Poona City (Poona infected).
37	530	Bahatur	Do.								1	3																		
											1		1																	
38	2335	Warwand	Shirawli								41	7	31	21	11														1	Probably imported case—no epidemic.
											28	21	16	19	1														1	
39	939	Kangaon	Do.								10	16	11																	
											7	24	13																	
40	1467	Bhir	Khed								13	3																		
											10																			
41	2824	Wade	Do.								19	8																		
											7	4																		
42	438	Karegaon	Do.								4	2																		
											8	2	17	14	1															
43	2010	Alandi	Do.								1	4	19	11	1															
											2	10	9																	
44	665	Shandgaon	Indapur								2	5	8																	
												20	45	12																
45	730	Narsingpur	Do.										14	40	10															
													2	1																
46	470	Sangvi Haveli	Haveli										2	1																
													8	9																
47	877	Dapodi	Do.										2	1																
													2	1																
48	1393	Aundh	Do.										17	8																
													1	1	13	4														
49	1347	Chinchwad	Do.											11	9															
													1	10	2															
50	831	Kasarsai	Do.										1	14	7															
													1			3														
51	1021	Bhandarda	Do.																			6								New part of Poona City.
													2			2						1							
52	432	Yerandawan	Do.										1			1						1	3							Contiguous to Poona—Municipal Plague Camps.
													1	13	13	9														
53	106	Borinadi	Shirawli										2																	
													9	16	9															
54	424	Dudgaon Raja	Do.										9	6	2															
													6	7	1															
55	1123	Chankhol	Maval										20	11	3															
													13	5	1															
56	1201	Wadgaon	Do.										15	3																
													3	14	3															
57	427	Tandali	Sirur										3	6	3															
													1	2																
58	513	Nirwa	Do.										3	10																
													1	9	10															
59	1121	Kanhe	Do.										4	7	4															
													10	17	10															
60	685	Kalthan	Indapur										3	11	10															
													24	47	21	10	1													
61	6287	Bavda	Do.										15	31	15	1	1				18	42	18	2						Probably infected from Nizampur-Khatki, (8 m. dist. which carried over all season—but Bavda may possibly have carried over though infected as early as December.
													2								26	31	13	1						
62	1603	Bhangaon	Purandhar										1																	
													6																	
63	739	Kamthadi	Do.										6																	

CHART No. III.—Subsequent Plague History of all villages in Poona District (population over 1901) in which epidemic commenced (on 1st January–31st June, 1903) in Plague Season, 1902–1910.

| | | | | 1902 | | | | | | 1904 | | | | | |

CHART No. IV.—Subsequent Plague History of all villages in Poona District (population over 300) in which epidemics commenced *late* (January-June 1904) in Plague Season, 1903-1904

	Pop.	Place.	Taluq.	1904 Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1905 Jan.	Feb.	Mar.	April	Remarks relative to source of infection in second season.
							Off Season.													
1	2761	Gherpadi	Haveli	2	5	3	1								6	5				Part of Poona Cantonment.
				1	5	3	1							—	4	5				
2	922	Parwati	Do.	3										4	7	2	6	4		Contiguous to Poona City.
				3		—								4	6	1	2	3		
3	2289	Nanded	Do.	6		9	3													
				4		4	2													
4	491	Kinahi	Do.	2	8															
				4	4															
5	1221	Delaadi	Bhimtadi	2	3															
				4	3															
6	1193	Pargaon Tf. Khed	Khed	2	4															
				4	2	12	6						7	12	12		4			
7	2287	Khandala	Mawal	4	6	13	2						3	13	12	—	4		—	On railway and main road, Poona-Bombay.
				1		14	4	6												
8	792	Khadkala	Do.	1		12	4	1												
				3																
9	919	Valvan	Do.	1																
				4	17	16														
10	709	Nane	Do.	2	9	10														
				6	29	35	1													
11	6470	Talegaon Dhamdera	Sirur	3	34	30	6													
				6	29	5														
12	689	Karegaon	Do.	4	17	7														
				4	2															
13	1046	Pimple Dumala	Do.	1	8															
				4	1															
14	1019	Karandi	Do.	1	3															
				2			**10**	**3**	**12**	13	14	24	21	1						
15	3369	Niemgaon-Ketki	Indapur	1			**9**	**0**	**6**	6	13	13	14	1						Carried plague over off season.
				9	21															
16	1022	Vadapuri	Do.	1	17															
				18	26	14	3													
17	392	Malshiras	Purandhar	13	20	8	3													
					9	16	2													
18	682	Seda	Indapur			15	3													
					1	9	**5**				62	92	24	1						
19	4495	Hadapsar	Haveli			6	**5**	—	—		35	77	19	2						Carried plague over off season.
					13	11	2													
20	874	Antroli	Do.		9	11	6													
					16	47	6													
21	1223	Pargaon	Bhimtadi		9	45	4													
					24															
22	1078	Induri	Mawal		16															
					15	17														
23	4325	Pimpalwandi	Junnar		10	10														
					4															
24	440	Varkute Bk.	Indapur		2															
					19	32	1													
25	1381	Dalaj	Do.		12	34	1			—										
					21	23														
26	370	Loni	Do.		14	28												—		
					5	28														
27	113	Sarati	Do.																	
					4	24	4													
					9	11	4													
28	323	Kalasi	Do.																	
					6	9	2													
					6	4														
29	342	Lonewadi	Do.		1	5														
						7	13	2												
30	320	Rui	Do.																	
						0	11	1							—		—			
						3														
31	1072	Bhamburda	Haveli												6					Part of Poona City.
						1										5				
32	872	Yerandawane	Do.			4									1	4				Outskirts of Poona, contains Municipal Plague Camp.
						6	**11**	**3**		9	102	24	17	3	1	4				
33	499	Mandavgaon	Sirur			5	**9**	**2**	—	3	68	19	13	2						Carried plague over off season.
						11														
34	369	Kasegaon	Bhimtadi			3														
						8														
35	369	Soritval	Do.			4														
						7	1													
36	309	Shetpal Ghule	Indapur			7	1													
							6													
37	1145	Mandur	Bhimtadi				4													
							12													
38	1236	Katti	Indapur				12													
							8								1		6	3		
39	364	Bharanpur	Bhimtadi				9								1		3	3		Probably infected in November, Bhimtadi taluq already severely infected.
							27	0												
40	1100	Mira Wigaj	Do.				16	1												
							4	2												
41	324	Agoti	Indapur				3	2												
							3													
42	729	Kuravli	Do.				1													
									5	2			8		7	3	2			
43	1729	Sonsar	Do.						2	0			4		6	3	2			Partially bridged the off season, otherwise first 7 cases may have been imported from Niemgaon-Ketki, 15 miles (see above) and subsequently infected from Baramatti (9 miles).

PLAGUE PROPHYLACTIC MEASURES DURING THE OFF-SEASON.

BY

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IN the light of our present knowledge of the circumstances which influence the persistence of plague infection during the off-season, I propose to discuss certain prophylactic measures which might be undertaken with a view of stamping the disease completely out of a large area of India.

In my previous work * dealing with the subject of the persistence of plague infection in villages during the off-season, observations were confined chiefly to Poona district and to some extent to the adjacent districts of Ahmednagar and Sholapur. We have reason to believe that in these two districts, as also in the neighbouring district of Satara, climatic and other conditions affecting plague epidemics do not differ very widely from those of Poona district so we may assume that the conclusions, arrived at in these papers, would apply as well to the remaining districts of this area.†

We will therefore confine ourselves to that portion of the Deccan covered by these four districts, *viz.* :—Poona, Ahmednagar, Sholapur and Satara.

We will endeavour to put forward a scheme which, given certain favourable conditions, we hope may prove both practical, economical and efficient whereby plague may be completely eliminated from the whole of this area. The question of the applicability of this scheme to other parts of India as well as the question of dealing with the subsequent re-importation of infection into this area will be deferred for future consideration.

The area we now have under consideration covers 21,353 square miles, it contains 4,613 towns and villages of which Poona City, including suburbs has a population of 158,856; Sholapur has 61,345; Ahmednagar 42,940; Satara 19,145; and six others have each a population of over 10,000. The total population of this area, according to the census of 1911, is 3,866,425.

The number of plague deaths that have occurred in each district between September 1896 and May 1912 is as follows :—Poona, 41,200; Ahmednagar 41,479; Sholapur 60,107; and Satara 214,061. The total number being 356,847 or nearly 10% of the population of this area.

In the table given below it will readily be seen that plague, either owing to the increasing immunity of rats or for other reasons, has been steadily decreasing in this area as well as in the whole of India during the last few years.

Three-Year period, June to May.	Plague deaths in area.	Three-year period, Jan. to December.	Plague deaths in all India.
1897–1900	50,909	1897–1899	309,110
1900–1903	103,940	1900–1902	960,532
1903–1906	120,591	1903–1905	3,078,761
1906–1909	54,194	1906–1908	1,829,093
1909–1912	26,757	1909–1911	1,538,286

It is important to bear this fact in mind. In former years when the whole of this area was extensively infected, it was quite impossible to hope for success from any measures except such as were merely palliative. Whereas now, with the steadily diminishing severity of plague epidemics, we may reasonably hope that the complete eradication of the disease from large areas will become less difficult in future years.

It is as well to remember, on the other hand, that although we might be able to show that it is possible to eradicate plague in certain favourable years and in a

* *Note.*—(*i*) The Importance of the Persistence of Infection in Certain Villages during the Off-plague Season (Nov. 1912).
(*ii*) Further Investigations into the Persistence of Plague Infection in the villages of Poona District during the Off-season (Jan. 1914).

† *Note.*—This assumption is supported by evidence to be found in Appendix II of this paper.

certain area, where conditions are perhaps, particularly favourable for such measures, it does not necessarily follow that we shall meet with equal success in any particular year in future, nor in every other district of India. There can be little doubt that in some districts of India, and in certain years more villages carry plague over the off-season than in others; the greater the number of such villages there are, the more difficult and expensive would our measures become.

In considering the prophylaxis of plague, it is well to bear in mind a few facts regarding the epidemiology of that disease. Plague in India, it must be remembered, is essentially a disease of the rat. Man is only occasionally and accidentally infected and takes no material part in the maintenance of the disease. It is an acute disease and a rat suffering from it either dies within a few days or else recovers completely; so that, in order to maintain the infection in a town, it is essential that the plague bacillus be constantly transferred from a sick to a healthy rat. The agency by which this takes place in India has been shown to be the rat flea (X. cheopis).

But, taken as units of infection, the *village* in the case of district plague can be compared with the *rat* in the case of town plague; we have seen * that in a town or village the period of infection is also strictly limited and plague seldom persists for more than a few consecutive months. Only in very large towns or cities does the disease appear to be capable of existing continuously for more than a year, and even such places are frequently free from infection for periods of several months. That there is no endemic centre for plague in Poona district is clearly shown in the two papers already referred to. In order that the existence of plague in a district may be maintained it would be necessary, therefore, for infection to be constantly transferred from one place to another. The agency by which this transference takes place is probably, in most instances, also the rat flea. It may, however, sometimes be transferred directly by the transportation of an infected rat. The relative importance of each mode of infection has not as yet been determined.

According then to the various ways in which the disease may be fought and the chief aim in each case, plague prophylactic measures may be divided into the following groups:—

(1) The prevention of spread to man:—
  (*a*) By inoculation.
  (*b*) By evacuation of infected areas.
  (*c*) By protection from fleas; either by suitable clothing or by destruction of fleas in houses.

(2) The prevention of spread from rat to rat in a town:—
  (*a*) By rat destruction; trapping, poisoning or by fostering the natural enemies of rats; thus reducing their number and so separating susceptible individuals by wider intervals.
  (*b*) By rendering houses and godowns rat-proof, and by diminishing the shelter and food-supply of rats.
  (*c*) By rendering houses more or less flea-free, by increasing light and ventilation and by the destruction of fleas in houses.

(3) The prevention of diffusion of infection from town to town in a district:—
  (*a*) By some form of a "Passport System" such as is carried out in the Madras Presidency.
  (*b*) By flea destruction in luggage and merchandise by means of heat, or by kerosine oil, etc.
  (*c*) By avoiding the transport of rats in merchandise.

These divisions are merely approximate and artificial, they overlap considerably. For instance the complete evacaution of a town, as also all measures which tend to prevent the spread of plague from rat to rat, would tend to prevent the diffusion of infection from town to town.

According to the results obtained by the above measures they may be either:— (1) Incomplete and palliative; or (2) Complete and radical.

This classification is also artificial and arbitrary. It serves our purpose well, however, in that it distinguishes between the type of measure which we contemplate and that which is usually applied. Since our present object is to propound a scheme for the *complete* eradication of the disease from a large area, it will be only with measures of the latter class that we have to deal. We will, however, briefly consider all measures including those the results of which are merely palliative.

Such preventive measures as are generally attempted in India have hitherto almost always been of the former type. Under this heading will come all *measures which aim at the prevention of spread of the disease to man* for these measures could not materially affect the spread of an epizootic amongst the rats.

* *Vide* papers already referred to.

We will, therefore, pass on to *measures which aim at the prevention of spread from rat to rat* in a town. Of these rat destruction is one of the most useful and generally applied in India. It is, as a rule, employed systematically only in the largest and most important towns of a district, chiefly for the purpose of diminishing the severity of an epizootic, and so indirectly also the epidemic amongst men. It has seldom been conducted on a sufficiently large scale to prevent a town from becoming re-infected or materially to assist in bringing an epizootic to an end when once started. In a large area it could only have a complete effect in eradicating the disease if all infected villages were dealt more or less simultaneously, and also before the disease has time to spread to other places in the district.

It should be noted here that plague is by far the most efficient rat destructor in nature. It would be particularly useful for our purpose for it is selective in its action, killing the more susceptible and leaving the more immune rats alive. The latter again would be capable of picking up infected fleas that have lost their host thus rendering these parasites harmless. Rat destruction by an epizootic of plague is indeed the natural method of eradicating the disease. We shall see presently how this powerful force of nature can be called to our assistance.

To render the most rat-infested houses and godowns in all the towns and villages of a large area, more or less rat-proof, so as to reduce the number of rats and thereby prevent the spread of plague amongst them, would be extremely costly and moreover take a long time to complete. When attempted on a small scale any such measures can only be regarded as incomplete and palliative.

Rendering houses more or less flea-free on a large scale is only of theoretical interest and the same objections apply to this as to the preceding measure.

We will now consider *measures which aim at the prevention of diffusion of infection from town to town* in a district. This may be effected by some form of a "Passport System" such as is employed in the Madras Presidency. It, however, could never be a complete measure unless some method were adopted of killing fleas in the clothing and luggage of all persons, healthy or otherwise, as well as in grain and other merchandise arriving from infected places. The only alternative would be to segregate all individuals and merchandise arriving from such places for a period exceeding the normal life of a flea.

Lastly, the prevention of the transport of infected fleas and rats in merchandise. To be effectual and complete this would not only require a large and expensive organisation but would also cause great inconvenience to individuals and interference with trade.

As practical measures, considered only from the point of view of eradicating the disease from a large area within a limited time, most of the methods mentioned above are therefore out of the question; though as palliative measures, carried out in certain limited areas where local circumstances permit each, no doubt, would be of some use.

The only one of these measures that will answer our purpose is rat destruction, but this will have to be carried out in a rational and systematic manner, in all infected villages, more or less simultaneously over the whole area. We shall now consider this measure.

The various charts contained in the two papers already referred to show clearly that a plague epidemic depending of course on the co-existing epizootic, can flourish, in this part of India, at almost any season of the year and is checked only during the few months of the off-season. The period of onset of the epidemic in any town or village is determined almost entirely by the time when infection is introduced, and its termination is brought about chiefly by the diminution of the rat population caused by plague itself.

The severity, course and duration of the epidemic are however considerably influenced by the climatic conditions and flea prevalence existing during the period when the place is in an infected state. When infection is imported late in the plague season, the epidemic, dependent on the epizootic, may be cut short and brought to an end at the commencement of, or during the off-plague season; if, however, the number of rats then remaining in the village is sufficient to maintain the epizootic, it may merely subside temporarily and recrudesce during the following plague season, when it would continue its course to a natural termination.

The off-season is thus by far the most suitable period for conducting operations aimed at the complete eradication of infection in any given area. We have seen, in the papers already referred to, that at this time of the year the number of villages that remain infected is comparatively small. In the part of India with which we are now dealing they form a very small proportion of the total number infected in any year. In most of these an epizootic of plague has already made a substantial reduction in their rat population so that in many, the disease is only just capable of maintaining its existence until conditions again become more favourable during the following plague season.

At this time of the year unfavourable climatic conditions and a low flea prevalence not only check the spread of the disease from rat to rat but also, perhaps to a still greater extent, hamper its diffusion from town to town. It is unusual for fresh towns to become infected at this season, which is perhaps due to the very limited length of life of a flea, when deprived of its food, in a hot and dry atmosphere.

Finally, the duration of the off-season in this area is at least three months. During this period, and even for some weeks preceding it, we would have ample leisure to visit and thoroughly investigate any places which we suspect of harbouring infection. If found infected, ample time would be at our disposal to carry out any measures we may devise for exterminating the disease.

The problem before us thus resolves itself into :—

(i) The detection of all villages which might be suspected of harbouring the disease during the off-season.

(ii) The reduction of the rat population of these villages to an extent which would separate or isolate susceptible individuals, or groups of individuals, sufficiently to prevent the spread of plague amongst them.

The success of the prophylactic measures which we contemplate would depend largely on the extent to which we can limit the number of suspected places in which it will be necessary to conduct our operations of rat reduction. The fewer such places there are the more effectually and thoroughly could they be dealt with, the less expensive would such measures be, and the less would they interfere with the comfort and prejudices of the people.

It will be necessary therefore to have some practice and to gain some experience in the detection of those villages which are likely to carry plague over an off-season, and in the elimination of those places which though infected late in the off-season are, for various reasons, unlikely to require more than casual observation during this period.

For this purpose the following method has been devised :—

In the various districts of this area a number of years were selected, and on charts similar to those I have already described in my previous paper, all plague cases and deaths were entered, which occurred during each of the six months, January to June, in any year. In other words all villages were taken which showed the presence of plague infection late in the particular plague season under review. From experience we know that these villages would include most of those that were about to carry plague infection over the subsequent off-season. Similar figures were then entered for the previous December in order to inidcate which villages were infected for the first time only in January, and in the case of large towns and cities we ascertained in which month their plague epidemics commenced.

The chart was then carefully studied, having regard to the problem that is now before us, and each village was considered in turn. We attempted to estimate the effect of the size (population) of the village and also of the duration of the epidemic on the chance which the disease would have of surviving the quiescent period in it. With the assistance of previous experience gained in the study of plague during the off-season in these districts, and of any local knowledge we might have of them, we then classified these villages arbitrarily into four groups and marked each place on the chart thus :—

Villages which required immediate rat reduction operations :—

(A) A village in which plague infection is almost certain to survive the off-season.

(B) A village in which plague will probably survive the off-season but about which there is some doubt.

Villages which necessitated only more or less careful observation or enquiry :—

(C) A village which may possibly carry plague over, and which will have to be kept under strict observation during the off-season.

(D) A village which is almost certain to be plague-free in spite of being infected late and which would necessitate only a few local enquiries.

When all villages in each chart had been thus marked, and not till then, these charts were completed for the first portion of the subsequent plague season, by tracing the plague history of each village to the end of October.

In this manner not only could we gain some experience and practice in separating those villages which are likely, to bridge the next off-season, from those which are not but we would also be able to judge, when their plague histories had been traced for the subsequent season, how far we had been successful in doing so. We would moreover be able to estimate to some extent, beforehand, the probabilities or otherwise of bringing our scheme to a successful issue, and also the amount of labour and expense that it would involve.

We will now examine the various charts thus obtained.

First Series.

In this series various years, prior to 1903, were selected for each district in which comparatively few villages were infected in the latter half of the plague season. This was done in order that the charts should not be too cumbersome, and also to demonstrate how simple the problem would have been on certain favourable occasions even during the earlier years of plague in India.

Poona district was omitted from this series for we already know, from a previous paper on this subject which villages bridged the off-season in these years.

CHART I.—(1) Ahmednagar District, 1899.

In this chart it will be seen that out of 13 villages infected late in the plague season, we were at once able to limit the number of places which would require immediate rat reduction operations to three, the remaining 10 were marked " D," *i.e.*, they were almost certain to be plague-free during the off-season and would necessitate only a few local enquiries. The subsequent plague history shows that we were probably correct in the latter assumption for the two places, which showed plague epidemics in the second season before the end of September were both adjacent to Ahmednagar and so were probably re-infected from that city. Of the three places in which we considered plague would probably bridge the off-season plague infection undoubtedly survived in two.

CHART I.—(2) Ahmednagar District, 1900.

In this chart we came to the conclusion that no village was likely to bridge the off-season and so none would require more than casual observation or enquiry. The subsequent plague history of this district shows that we were correct in our prognosis.

CHART I.—(3) Ahmednagar District, 1902.

The same remarks, as above, apply to this chart.

CHART I.—(4) Sholapur District, 1899.

In this chart 16 villages are shown ; of these we came to the conclusion that 13 would require mere observation or enquiry and in this we proved to be correct. Of the three villages which we considered would require immediate rat reduction operations, one, *viz.*, Kandalgaon undoubtedly bridged the off-season.

Kandalgaon appears to have been the chief source of infection of the whole of Sholapur district during the following plague season and so probably accounted for most of the 2,777 deaths which occurred in that district during the season 1899-1900. Many of these lives might thus have been saved, had this place been dealt with in time. It is a small village, so the epizootic which prevailed during March, April and May must have reduced the rat population by the end of May to the minimum requisite for the maintenance of plague ; but a small additional reduction of their numbers would have been necessary to prevent the continuance of the epizootic in that place. This assumption is supported by the fact that human plague did not again make its appearance till August and then only a very mild epidemic resulted in which 13 deaths were reported, spread over August, September and October. The examination of this chart is therefore of some interest.

CHART I.—(5) Sholapur District, 1900.

In this 25 places are shown, of which we decided that only two would require rat destruction. Subsequent history shows that even in these two places, Sholapur and Karkamb, plague did not survive the off-season.

CHART I.—(6) Sholapur District, 1902.

In this 24 places are shown. Of these we decided that 17 would require only casual observation or local enquiry ; the subsequent history shows that in sixteen of these plague died out during the off-season, for Boramani was probably reinfected, or the plague cases were imported from the three other villages in the same taluq which carried plague over the previous off-season, and the town of Barsi was probably re-infected in October in the same way. In only one of the 17, *viz.*, Togarhalli, a very small village with a population of 246, local enquiry would no doubt have elicited the fact that infection was still present at the end of the off-season and owing to its small size could easily have been disposed of within a few days. Of the remaining 7 villages in which rat reduction was considered necessary, only two appear to have bridged the off-season and these being villages of moderate size could easily have been dealt with.

CHART I.—(7) Satara District, 1900.

In this chart 29 villages are shown and of these we concluded that 25 were not likely to bridge the off-season so would merely require observation during that time. Subsequent information proved that we were correct. The remaining four we considered would require rat destruction operations. Their later history shows

that even these failed to carry plague over the off-season. The district was, indeed, not infected again till the following November.

CHART I.—(8) Satara District, 1901.

In this only six places are marked, of these we decided that two would require rat reduction, whereas the remaining four, including Satara, would require only observation and enquiry. Subsequent information showed that we were probably correct, for Satara town itself was not reinfected till the following September in which month only seven cases were reported. Considering that July and August are the most favourable months for plague in this part of India, it is probable that Satara derived its infection directly or indirectly from either Kupwad or Sap which bridged the previous off-season, or from about 50 other villages * in the same district which had already become infected by the month of September.

During this plague season 34,583 deaths from plague occurred in Satara district and it is probable that many of these lives would have been saved had successful rat reduction operations been carried on in the two small villages of Kupwad and Sap during the previous off-season.

A summary of all the 126 places contained in the charts of the first series is seen in the following table. Villages marked (A) and (B) are those which we considered would require immediate rat reduction operations and those marked (C) and (D) merely observations and local enquiry.

District.	Villages marked A & B.	A & B villages which carried over.	Villages marked C & D.	C & D villages which carried over.
Ahmednagar, 1899, 1900, 1902 ..	3	2	23	..
Sholapur, 1899, 1900, 1902 ..	12	3	53	1
Satara, 1900, 1901	6	2	29	..
All districts	21	7	105	1

It will be observed that of the 21 places in which we considered immediate rat reduction necessary to prevent plague, only seven carried plague over so that our operations would have extended to only three times as many as subsequent events proved to be necessary. Of the 105 villages which we would have kept merely under observation, only one, Togarhalli carried plague over the off-season. As this was marked " C " in the chart, which means that it would have been kept under strict observation, and as its population numbered only 246, there can be little doubt that infection in this place would have been discovered in time to deal with its rats before the next plague season commenced.

Second Series.

In this series of charts which are those of Poona district only, the three most recent years were taken for which complete statistics were available, these were —1910, 1911 and 1912. In this series only figures for the number of deaths, and not attacks, are available.

CHART II.—(1) Poona District, 1910.

In this chart 25 places are shown of which we marked four as likely to bridge the off-season. Subsequent history shows that in none of the 25 villages did infection persist throughout the off-season so that we were at any rate quite correct in eliminating 21 of these as not requiring rat destruction.

CHART II.—(2) Poona District, 1911.

Of the 18 villages in this chart, three were marked as likely to carry plague over. Of these only two, *viz.*, Poona City and Lonavla bridged the off-season. Of the 15 which we marked for observation only one, Talegaon situated on the railway between Poona and Lonavla, showed plague during the second season. Since however there was only one death reported in January which was followed by seven months' freedom from the disease and since it was not attacked again till August by which time Poona on the one side and Lonavla on the other were both infected, it is probable that the first was only an imported case and not due to local infection.

CHART II.—(3) Poona District, 1912.

In this year 43 villages showed infection in the latter half of the plague season; 1911-12. Of these three were marked as likely to carry plague over, *viz.*, Poona City, the Cantonment and Kirkee. Poona, with its various suburbs, proved afterwards

* *Note.*—In this year many of these villages apparently derived their infection from across the borders of Satara district, *viz.*, from Sangli and Kolhapur States.

to be the only place in the entire district which carried plague over this off-season, for of the 39 others which were marked as not likely to do so, not a single one bridged this period.

In the second series of charts 86 places were infected in the latter half of the plague seasons of 1909-10, 1910-11 and 1911-12. A summary of the results obtained in this series of charts is seen below :—

District.	Villages marked A & B.	A & B villages which carried over	Villages marked C & D.	C & D. villages which carried over
Poona District, 1909-10, 1910-11 & 1911-12	10	5	76	..

It will be seen that we were correct in eliminating 76 of the 86 villages as being unlikely to bridge the following off-season. Of the ten places in which we considered that plague would probably bridge the off-season in these three years, our prognosis was correct in the case of five.

It is obvious, therefore, that by this method of detecting the villages which are likely to bridge the off-season, we are enabled considerably to reduce the labour and expense involved in carrying out any prophylactic measures during the quiescent period of plague.

Third Series.

At the time when this paper was being written and when these charts were being compiled, that is in the month of July 1913, plague returns for all the four districts, up to the last week in June had just been received. We have an opportunity, therefore, of making a forecast for the plague season of 1913-14 without any further information being available as to which places were about to carry infection over the off-season in the area under consideration.

Charts similar to those described in the first and second series were constructed for each of the districts in this area. They would, therefore, show all places from which plague cases and deaths were returned during the second-half of the past plague season (*i.e.*, January to June 1913). When these had been completed they were marked, as on the previous occasions, according to the probability or otherwise of infection surviving in each place.

CHART III.—(1) Poona District, 1913.

This shows fourteen infected places. Of these we came to the conclusion that plague would almost certainly survive in Poona City (marked A) and probably also in Ghorpadi (marked B), four others would require strict observation (C), and eight would require local enquiries (D). Our action would naturally be considerably modified, in regard to the last four marked on the chart which returned a few cases during the off-season, if these cases were found to be imported or of local infection.

CHART III.—(2) Ahmednagar District, 1913.

In this chart we considered that Devi Bhogari would probably require rat destruction, whereas the remaining four would require only observation or local enquiry. Here again our action would perhaps be influenced when we ascertain their population and how many of these cases were imported and not local. In the cases of Kharda, there appears to have been some mistake in the returns or in the diagnosis for 29 cases were reported for December and January with no deaths.

CHART III.—(3) Satara District, 1913.

In this district there were 28 infected places, of which we considered five would require immediate measures whilst 23 would require only observation and local enquiry. Here again our action might be influenced by our knowledge of the source of infection of the cases reported by Eksal, Dahigaon, Padali and Mangalpur.

In Sholapur District there was no plague.

The summary of the contents of these three charts might be expressed thus :—

No. of places that would require immediate rat destruction ..	8
No. of places that would require strict observation during the off-season	7
No. of places in which a few local enquiries would probably suffice ..	32
Total in whole area ..	47

Rat reduction operations during the past off-season, according to these charts would, therefore, have been necessary in only eight places. It is not likely to have been required in many more than eight for if local enquiry showed that it would be

necessary in, for example, Rawangaon and Bahul (Poona), further information might also show that it would be unnecessary in Devi Bhogari (Ahmednagar) or in Pulshi (Satara).*

In addition to these eight villages some few others may have become infected at the end of the plague season,or during the off-season, from neighbouring places before infection in these had terminated naturally or had been brought to an end by the above measures. These may not have returned human plague during, or immediately previous to the off-season and so would have escaped our observation. In order to eliminate plague from the whole of this area, it will be necessary then to make a vigorous attack on these few villages, if there should be any such, as soon as they show evidence of indigenous plague during the following plague season, and before the infection has time to spread from them to the other villages of the district.

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* *Note.*—Subsequent information shows that of the eight places in which immediate rat reduction was considered necessary five carried plague over the off-season and of the seven places which required strict observation, infection was carried over in only one. Of the 32 in which it was considered a few local enquiries would suffice none bridged the off-season.

APPENDIX I. ½

COMPARING THE SUBSEQUENT PLAGUE HISTORY OF ALL PLACES IN POONA DISTRICT INFECTED (*a*) EARLY (IN DECEMBER) WITH THOSE INFECTED, (*b*) LATE (DURING OR AFTER JANUARY) IN THE PLAGUE SEASONS OF 1909-10, 1910-11, 1911-12.

Information derived from the three charts of the *Second Series* confirms the conclusions arrived at in the paper entitled " Further Investigations into the Persistence of Plague Infection in the Villages of Poona District during the Off-season,"* for amongst the 86 places mentioned in these charts 25 were infected or returned plague cases before January; in only three of these, epidemics occurred during the next plague season, and these were Poona City, Poona Cantonment and Kirkee. In Kirkee the first few cases were probably imported from Poona City and in the case of the Cantonment, the disease may possibly have died out at the end of the plague season and infection may have been re-introduced from either Poona City or Kirkee in August or September. These three apparent exceptions to the rule need not therefore receive serious consideration (*see* table).

Amongst the 61 which returned plague cases for the first time, either during or after the month of January, infection persisted in only two, for Khandala may be neglected (for explanation *see* chart) and Talegaon was probably reinfected from either Poona or Lonavla as has already been explained.

APPENDIX I.

The following table summarises the information obtained from the three charts.

When infected.	NOT INFECTED, 2ND SEASON.		VILLAGES INFECTED, 2ND SEASON.			Total.	REMARKS.
			INFECTION PROBABLY IMPORTED.		INFECTION NOT IMPORTED.		
	No. cases.	Less than 3 cases (imported).	On railway or main road.	Part of Poona.	Carried over Off-Season.		
Early epidemic..	21	1	..	1†	2*	25	*Poona city and Kirkee (latter probably late infection).
Late epidemic ..	55	3	1‡	..	2	61	†Poona cantonment.(?) Carried over or re-infected from Poona city. ‡ Talegaon.
TOTAL ..	80		2		4	86	

* *Vide* Proc. Second All-India Sanitary Conference, Vol. III (1912).

APPENDIX II.

COMPARING THE SUBSEQUENT PLAGUE HISTORY OF ALL PLACES MENTIONED IN THE FIRST SERIES OF CHARTS, INFECTED, (*a*) EARLY, *i.e.*, IN DECEMBER, WITH THOSE INFECTED, (*b*) LATE, *i.e.*, DURING OR AFTER JANUARY, IN EACH YEAR.

One hundred and twenty-six places are mentioned in this series and of these 45 were infected early and 81 late in the plague season.

Of the 45 places infected early (*i.e.*, in December) 43 returned no plague cases whatever during the second year. Of the two remaining places which showed the presence of plague during the second year, one Satara town, the capital of Satara district, was not re-infected till September by which time about 50 villages in the same district were already infected. It appears, therefore, that in this place also plague had probably died out at the end of the first plague season.

In only one of the 45 villages, *viz.*, Ahmednagar was plague carried over the off-season. An examination of Chart No. I (*First Series*) will, however, show that Ahmednagar City was probably not infected till February and if so should, in reality, have been included amongst the places in which epidemics commenced late in the plague season (*see* table).

Of the 81 villages infected late in the plague season, there was no second epidemic in the case of 69 ; in the case of five in which a second epidemic occurred, four were all situated in taluqs which had already been extensively infected before their epidemics commenced and the fifth (Barsi) is a large town and an important trade centre situated on the railway. It is probable that, even amongst the 81 villages infected late in the plague season, infection died out completely at the end of the plague season in 74, and that in only seven did infection survive the off-season.

Information derived from the *First Series* of charts, therefore, confirms the conclusions arrived at in the former paper, referred to in Appendix I, and it also shows that these conclusions can be applied, not only to Poona District, but also to the neighbouring districts of Ahmednagar, Sholapur and Satara.

APPENDIX II.

TABLE (1).

Table showing the number of villages of Ahmednagar, Sholapur and Satara Districts mentioned in the First Series of charts which were infected early *(December) in each particular plague season and the probable source of their infection during the following plague season.*

District and Plague season.	VILLAGES NOT INFECTED, 2ND SEASON.		VILLAGES INFECTED, 2ND SEASON.				Total number of villages.	REMARKS.
			INFECTION PROBABLY IMPORTED.			INFECTION NOT IMPORTED.		
	No cases or deaths in second season.	Less than 3 cases in second season (no epidemic).	On line of railway.	Capital city and large trade centre.	Near Capital city or in same taluq (already infected).	Carried over off-season.		
Ahmednagar District, 1898-99, 1899-1900, 1901-1902.	9	..	..	..	..	1 *	10	* Ahmednagar city probably not infected till February (*i.e.*, late infection).
Sholapur District, 1898-99, 1899-1900, 1901-1902.	17	..	..	..	..	..	17	....
Satara District, 1899-1900, 1900-1901.	17	..	..	1 †	..	..	18	† Satara Town. Two other villages in same Taluq and 50 others in same district already infected in September.
TOTAL ..	43	..	..	1	..	1	45	....
	Not infected second season =43.		Infected, second season but infection probably imported =1.			Carried over off-season =1.	45	....

APPENDIX II.

TABLE (2).

Table showing the number of villages of Ahmednagar, Sholapur and Satara districts mentioned in the First Series of charts which were infected late *(January to June) in each particular plague season and the probable source of their infection during the following plague season.*

District and Plague season.	VILLAGES NOT INFECTED, 2ND SEASON.		VILLAGE INFECTED, 2ND SEASON.				Total number of villages.	REMARKS.
			INFECTION PROBABLY IMPORTED.			INFECTION NOT IMPORTED.		
	No cases or deaths in second season.	Less than 3 cases in second season (no epidemic).	On line of railway.	Capital city and large trade centre.	Near Capital city or in same taluq (already infected).	Carried over off-season.		
Ahmednagar District, 1898-99, 1899-1900, 1901-1902.	12	..	..	..	3 *	1	16	* Ahmednagar Cantonment and Bhingar both continuous to Nagar city (infected) and Kedgav not infected till October also situated in Ahmednagar taluq (infected).
Sholapur District, 1898-99, 1899-1900, 1901-1902.	42	..	1 †	..	1	4	48	† Barsi—Large town and important trade centre.
Satara District, 1899-1901.	14	1	..	..	..	2	17	....
TOTAL ..	68	1	1	..	4	7	81	....
	Not infected, second season =69.		Infected second season but infection probably imported =5.			Carried over off-season =7.	81	....

AHMEDNAGAR DISTRICT.

FIRST SERIES—CHART No. I.

1899.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.		Remarks.
2,300	Chinchodi P. ...	Ahmednagar	28 / 21	18 / 11	4 / 1	0 / 1	...	...	...	...	...	...	...	D	
789	Savedi	Do. ...	...	13 / 12	2 / 3	...	...	...	...	...	...	...	...	D	
1,239	Kedgav	Do. ...	...	2 / 2	..	...	...	...	...	...	...	...	10 / 8	D	Probably re-infected from Ahmednagar (same taluq).
328	Sonewadi	Do. ...	...	3 / 3	8 / 7	3 / 2	...	...	...	...	...	...	...	D	
250	Barhanagar ...	Do. ...	...	3 / 1	8 / 3	0 / 1	...	...	...	...	...	...	...	D	
358	Hivregaon	Do. ...	...	...	1 / 1	...	...	...	...	...	...	...	...	D	
36,083	Ahmednagar City ..	Do. ...	1 / 1	...	7 / 5	16 / 12	7 / 6	...	...	2 / 1	201 / 164	805 / 571	952 / 709	A	Large town. Headquarters of District not infected till February and so was certain to carry over.
...	Shende	Do. ...	...	...	1 / 1	...	...	...	...	...	...	...	...	D	
5,606	Ahmednagar Cantt.	Do. ...	...	...	...	1 / 1	...	...	...	...	8 / 5	53 / 26	63 / 39	D	Probably re-infected second year from Ahmednagar (same taluq).
...	Burudgav ...	Do. ...	...	...	...	4 / 2	...	...	...	...	...	...	...	D	(?) Population.
...	Maliwada	Do. ...	...	...	...	3 / 3	...	...	...	...	...	...	...	D	(?) Population.
5,490	Bhingar	Do. ...	...	...	..	...	2 / 2	...	...	...	...	30 / 26	44 / 29	B	(?) April cases imported. Probably re-infected from Nagar to which it is contiguous.
908	Arangaon	Do. ...	...	...	...	...	...	5 / 4	14 / 11	8 / 3	29 / 19	29 / 16	1 / 1	A	Carried plague over off-season.

AHMEDNAGAR DISTRICT.

FIRST SERIES—CHART No. II.

1900.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.		Remarks.
5,490	Bhingar	Ahmednagar	0 / 6	2 / 1	...	...	...	...	...	...	...	..	...	D	
4,916	Jeur	Do. ...	7 / 5	21 / 10	2 / 2	17 / 15	31 / 26	...	...	...	...	...	...	C	Commenced epidemic in December and not a very large village so not likely to carry over.
68	Athward	Do. ...	7 / 3	1 / 1	...	...	...	...	...	...	...	...	...	D	
741	Pokhadi	Do. ...	5 / 4	1 / 2	...	...	1 / 1	...	...	...	...	...	...	D	
1,116	Nagardevla ...	Do. ...	...	1 / 0	...	...	...	...	...	...	...	...	...	D	
507	Sarola Buddi ...	Do. ...	2 / 1	1 / 0	...	...	...	...	...	...	...	...	...	D	
7,800	Pathardi	Shevgaon ...	15 / 10	41 / 34	29 / 16	1 / 0	...	...	...	...	...	...	...	D	
36,083	Ahmednagar City ...	Ahmednagar	28 / 20	1 / 0	...	...	...	...	...	...	...	...	...	D	
5,606	Ahmednagar Cantt..	Do. ..	2 / 1	1 / 0	...	...	...	...	...	...	...	...	...	D	
2,300	Chichondi.	Do. ...	...	1 / 1	...	...	...	...	...	...	...	...	...	D	

(No plague in District till 1901.)

AHMEDNAGAR DISTRICT.

FIRST SERIES—CHART No. III.

1902.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
2,709	Rasin	Karjat ...	...	7 / 7	...	...	...	...	...	...	...	...	...	D
1,151	Koregaon	Do. ...	...	3 / 3	...	...	...	...	...	...	..	..	...	D
...	Kasara	Sangamner	...	...	3 / 3	...	...	...	...	...	...	...	...	D

SHOLAPUR DISTRICT.

FIRST SERIES—CHART No. IV.

1899.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
1,660	Wadala /... ...	Sholapur ...	29 / 21	16 / 13	...	6 / 5	...	...	...	...	...	...	...	D
642	Sahala	Do. ...	...	20 / 16	3 / 3	...	...	...	...	...	...	...	...	D
...	Tambol	Mudha ...	55 / 44	5 / 6	..	...	...	...	...	...	...	...	...	D
...	Saundana	Do.	15 / 11	37 / 36	2 / 5	...	..	...	...	...	...	...	...	D
870	Dahitne	Barsi ...	4 / 3	2 / 2	...	...	...	...	...	...	...	...	...	D
...	Ghanegaon ...	Do. ...	...	31 / 20	...	...	...	...	...	...	...	...	...	D
224	Chikli	Mudha ...	...	0 / 1	...	...	...	...	...	...	...	...	...	D
989	Hiraj	Sholapur ...	...	12 / 9	6 / 3	5 / 7	1 / 1	...	...	...	...	...	...	D
583	Bhambevadi ...	Mudha ...	...	19 / 13	7 / 6	...	...	...	...	...	...	...	...	D
678	Kamti Khurd ...	Sholapur ...	...	...	12 / 8	1 / 1	...	...	...	...	...	...	...	D
482	Nandur	Do. ...	...	...	18 / 14	3 / 3	0 / 1	...	...	...	...	...	...	D
2,286	Salghar	Do. ...	...	...	2 / 2	..	...	...	...	...	...	...	...	D
...	Kotale	Do. ..	...	.	...	12 / 12	...	...	...	...	...	...	...	B (?) Population, if large village, will probably carry over.
850	Raleras	Barsi ...	...	...	...	7 / 4	...	...	...	...	...	...	...	C
1,589	Kandalgaon ...	Sholapur ...	...	...	...	17 / 8	11 / 12	3 / 3	...	...	10 / 7	1 / 4	2 / 2	A Carried over.
1,150	Wangi	Do. ...	...	...	...	...	...	25 / 23	2 / 2	...	...	...	...	A

SHOLAPUR DISTRICT.

FIRST SERIES—CHART No. V.

1900.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
62,329	Sholapur	Sholapur ...	480 / — / 443	461 / — / 430	146 / — / 139	70 / — / 58	24 / — / 26	...	...	...	...	...	...	B Epidemic commenced in September 1899 so not very likely to carry over.
976	Tirhe	Do. ...	3 / — / 3	10 / — / 9	...	...	...	...	...	...	...	...	...	D
1,883	Ahirwadi	Do. ...	56 / — / 38	31 / — / 24	8 / — / 5	...	...	...	...	...	...	...	...	D
2,410	Kumbhari	Do. ...	50 / — / 43	4 / — / 3	...	...	...	...	...	...	...	...	...	D
3,486	Mandrup	Do. ...	87 / — / 78	34 / — / 32	5 / — / 5	...	...	..	...	...	...	..	...	D
1,766	Musti	Do. ...	5 / — / 4	10 / — / 11	4 / — / 1	3 / — / 5	...	...	...	...	...	...	..	D
635	Kamti	Do. ...	25 / — / 15	33 / — / 28	...	...	...	...	...	...	...	...	...	D
805	Shelgi	Do. ...	9 / — / 6	29 / — / 24	...	...	...	...	...	...	...	...	...	D
844	Shingadgaon ...	Do. ...	...	0 / — / 1	...	...	...	...	...	...	...	...	...	D
1,498	Dongaon	Do. ...	...	26 / — / 17	4 / — / 4	5 / — / 3	...	...	...	...	...	...	...	D
1,625	Anjangaon ...	Mudha ...	17 / — / 11	7 / — / 5	...	...	...	...	...	...	...	...	...	D
1,566	Nimbargi	Sholapur ...	18 / — / 18	8 / — / 7	...	...	...	...	...	...	...	...	...	D
...	Degaon	Pandharpur	...	5 / — / 4	7 / — / 4	13 / — / 11	...	...	...	...	...	...	...	C (?) Population. If *large* town, then will probably carry over.
881	Sawleshwar ...	Sholapur ...	...	12 / — / 12	...	...	...	...	...	...	...	...	...	D
1,589	Kandalgaon ...	Do. ...	...	14 / — / 19	3 / — / 2	...	...	...	...	...	...	...	...	D
...	Tamdardi	Pandharpur	...	6 / — / 6	...	...	...	...	...	...	...	...	...	D
41	Pathri	Sholapur ...	...	10 / — / 6	1 / — / 0	...	...	...	...	...	...	...	...	D
942	Kamatha ...	Do. ...	...	..	23 / — / 16	0 / — / 1	...	...	...	...	...	...	...	D
4,155	Pangaon	Barsi ...	...	...	5 / — / 4	...	...	...	...	...	...	...	...	D
...	Karkamb	Pandharpur	...	...	35 / — / 27	6 / — / 3	...	...	...	...	...	...	...	B (?) Population. If large town, then will probably carry over.
1,199	Anrad	Sholapur ...	...	...	8 / — / 8	..	..	...	...	...	...	...	...	D
470	Hipargi	Do. ...	...	...	11 / — / 4	3 / — / 4	...	...	...	...	...	...	...	C (?) Very small village so not likely to carry over.
468	Bankalge	Do. ...	...	...	...	9 / — / 6	...	...	...	...	...	...	...	D (?) Very small village so not likely to carry over.
859	Bohali	Pandharpur	...	...	...	6 / — / 6	...	...	...	...	...	...	...	C (?) Very small village so not likely to carry over.
522	Doddi	Sholapur ...	...	...	...	4 / — / 3	1 / — / 1	...	...	...	...	...	...	D (?) Very small village so not likely to carry over.

SHOLAPUR DISTRICT.

FIRST SERIES—CHART No. VI.

1902.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.		Remarks.
74,521	Sholapur Town ...	Sholapur ...	29	393	639	432	31							A	Epidemic commenced in December, so almost certain to carry over.
			19	264	527	347	22	...	...	...	...	...	..		
840	Kardehali	Do. ...	37	1	3									D	
			28	1	1	...	...	...	...	...	...	...	..		
1,171	Darganpali ...	Do. ...	...	87	49									D	
				72	49	...	...	...	...	...	...	...	...		
3,655	Mandrup	Do. ...	...	16	123	150	40							B	Commenced early and had fairly severe epidemic so not very likely to carry over.
				9	93	126	35	...	...	...	...	...	...		
2,704	Boramani	Do. ...	...	72	75	5						4		B	Boramani probably reinfected from one of several infected villages in same taluq.
			...	43	52	8	...	...	...	...	...	4	...		
1,463	Dongaon	Do. ...	...	28	48	7								D	
				16	43	6	...	...	...	...	...	...	...		
3,125	Hotgi (Station) ...	Do. ...	..	1	...	...	...	...	...	..	...	..	...	D	
2,916	Kumbhari... ...	Do. ...	0	1	...	...	...	...	...	...	...	...	...	D	
			1	2											
2,037	Narkhad	Mudha ...	...	2	...	...	...	...	...	...	...	...	...	D	
				1											
5,082	Budhahal (Relief Camp)	Sangola ...	...	3	2									D	
				2	1	...	...	...	...	...	...	...	...		
2,293	Nazare	Do. ...	...	2										D	
				1	...	...	...	...	...	...	...	...	...		
766	Tirth	Sholapur ...	...	...	19	10	0							C	
					10	10	1	...	...	...	...	...	...		
363	Vadgaon	Do. ...	...	...	7	19								C	
					3	17	...	...	...	...	...	...	...		
730	Pahani	Do. ...	...	...	1									D	
					1	...	...	...	...	...	...	...	...		
20,781	Barsi	Barsi ...	...	...	3								17	D	Large and important town on railway, so probably re-infected from one of many villages in district already infected in October.
					2	...	...	...	...	...	...	...	13		
467	Nandri	Sholapur ...	...	..	7	10	0							C	
					0	9	1	...	...	...	...	...	...		
756	Gundewadi ...	Sangola ...	...	...	3									D	
					1	...	...	...	...	...	...	...	...		
236	Kegaon	Sholapur ...	...	...	...	9	1							D	
						5	1	...	...	...	...	...	...		
451	Banegaon	Do. ...	...	...	...	1	..	...	...	...	...	...	...	D	
						1	2			13	74	108	29		
1,473	Achegaon	Do. ...	...	...	...	1	3	...	...	10	50	95	21	B	Carried over.
827	Shelgi	Do. ...	...	...	...	...	24	...	...	...	...	...	...	B	
							13								
2,784	Kasegaon	Do. ..	...	...	...	...	11	7	...	...	..	...	...	A	
							8	7							
2,246	Mangrol	Do. ...	...	...	...	...	23	1	...	..	14	165	172	A	Carried over.
							21	1			8	81	131		
246	Togarhalli ...	Do. ...	...	...	..	...	...	4	...	7	9	1	...	C	(?) Very small village so not likely to carry over, but nevertheless did so.
								3		6	9	1			

SATARA DISTRICT.

FIRST SERIES—CHART No. VII.

1900.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
5,733	Kale	Karad ...	19 / — / 17	37 / — / 31	9 / — / 7	5 / — / 4	...	...	...	...	...	...	...	D
1,717	Kolewadi	Do. ...	23 / — / 16	3 / — / 4	...	...	...	...	...	...	...	...	...	D
1,663	Helgaon	Do. ...	3 / — / 2	5 / — / 5	4 / — / 3	...	...	...	...	...	...	...	...	D
1,543	Sawarde	Tasgaon ...	5 / — / 4	1 / — / 2	...	...	...	...	...	...	...	...	...	D
487	Kapri	Valva ...	3 / — / 5	3 / — / 3	...	...	...	...	...	...	...	...	...	D
4,184	Dudhagaon ...	Do. ...	...	10 / — / 5	10 / — / 11	3 / — / 2	...	...	...	...	...	...	...	B Doubtful. Commenced early and not a very large town.
2,908	Bhendawade ...	Khanapur ...	28 / — / 25	9 / — / 4	...	...	...	...	...	...	...	...	...	D
4,469	Boodhan	Wai ...	...	1 / — / 1	...	...	...	...	...	...	...	...	...	D
4,892	Mandrul	Patan ...	5 / — / 5	1 / — / 1	...	...	...	...	...	...	...	...	...	D
1,686	Vehe	Do. ...	16 / — / 9	14 / — / 13	...	...	...	...	...	...	...	...	...	D
1,438	Medha	Jawali ...	8 / — / 6	7 / — / 6	...	...	...	...	...	...	...	...	...	D
253	Kudal	Do. ...	...	5 / — / 5	...	...	...	...	...	...	...	...	...	D
25,749	Satara	Satara ...	...	13 / — / 13	22 / — / 15	52 / — / 44	21 / — / 20	4 / — / 4	...	...	...	...	1 / — / 0	A Commenced only in January so very likely to carry over. November figures= $\frac{1}{5}^{8}$, so infection probably reimported only in October.
3,480	Umbraz	Karad ...	...	20 / — / 13	3 / — / 3	...	...	...	...	...	...	...	...	D
1,068	Jarandi	Tasgaon ...	2 / — / 3	4 / — / 4	...	...	...	...	...	...	...	...	...	D
1,076	Dhawali	Valva ...	3 / — / 2	2 / — / 2	...	...	...	...	...	...	...	...	...	D
1,264	Khatgun	Khatav ...	12 / — / 13	4 / — / 4	...	...	...	...	...	...	...	...	...	D
226	Kurultigai ...	Satara ...	...	1 / — / 1	...	...	...	...	...	...	...	...	...	D
1,812	Koregaon	Valva ...	15 / — / 12	2 / — / 0	...	...	...	...	...	...	...	...	...	D
1,959	Mahuli	Khanapur ...	...	24 / — / 16	20 / — / 18	4 / — / 3	...	...	...	...	...	...	...	B Doubtful. Commenced early and moderate sized village, so not very likely to carry over.
3,646	Charegaon ...	Karad ...	16 / — / 14	4 / — / 4	1 / — / 1	...	...	...	...	...	...	...	...	D
1,185	Riswad	Do. ...	...	5 / — / 3	7 / — / 8	...	...	...	...	...	...	...	...	D
2,161	Mahimangad ..	Man ...	...	9 / — / 6	4 / — / 4	...	...	...	...	...	...	...	...	D
363	Beloshi	Javli ...	...	1 / — / 1	1 / — / 1	...	...	...	...	...	...	...	...	D
1,410	Bisur	Tasgaon ...	2 / — / 1	...	1 / — / 0	...	...	...	...	...	...	...	...	D
1,060	Humgaon ...	Javli ...	...	...	5 / — / 5	...	...	...	...	...	...	...	...	D
5,334	Masur	Karad ...	...	...	2 / — / 1	...	...	...	...	...	...	...	...	D
1,054	Wajegaon ...	Khanapur ...	...	...	6 / — / 6	5 / — / 5	...	...	...	...	...	...	...	B Commenced fairly late and fair sized village so should carry over.
1,471	Nindhal	Khatav ...	...	...	...	...	...	1 / — / 1	...	...	...	...	...	D (?) Imported or local infection.

SATARA DISTRICT.

FIRST SERIES—CHART No. VIII.

1901.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
25,749	Satara Town ...	Satara ...	46 / 15	71 / 22	41 / 17	21 / 13	2 / 3	...	...	...	...	7 / 3	160 / 106	C Commenced in November 1900 so not likely to carry over, re-infection from two other villages in same District in September or 56 others infected in the whole District.
1,227	Palshi	Wai ...	16 / 9	3 / 3	...	...	...	...	...	...	...	...	...	D
3,442	Koregaon ...	Koregaon ...	18 / 8	27 / 19	...	5 / 5	...	...	...	...	...	...	...	C
761	Yeksal	Do. ...	...	...	...	3 / 3	...	...	...	...	...	...	...	C
2,207	Kupwad	Tasgaon ...	...	...	...	3 / 3	11 / 8	...	5 / 2	50 / 28	55 / 36	117 / 67	79 / 57	A Certain to carry over and did so.
1,447	Sap	Koregaon ...	...	...	...	...	8 / 4	2 / 2	...	...	...	149 / 116	77 / 66	A Probably carry over, (?) re-infection in September.

POONA DISTRICT.

SECOND SERIES—CHART No. I.

1910.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
1,419	Kalamb	Junnar ...	6	3	...	...	...	...	...	...	...	...	...	D
845	Madha	Do. ...	...	10	2	...	...	...	...	...	...	...	...	D
1,019	Nandura	Do. ...	...	6	...	...	...	...	...	...	...	...	...	D
4,189	Narayangaon ...	Do. ...	...	1	...	2	...	...	...	...	...	...	...	B Large village, so if local cases, would probably carry over, but did not.
1,049	Nirgude	Do. ...	...	3	2	2	...	...	...	...	...	...	...	B Late epidemic and not severe so may carry over.
3,788	Pabal	Sirur ...	...	3	2	...	...	...	...	...	...	...	...	D
904	Amalas	Haveli ...	...	5	2	...	...	...	...	...	...	...	...	D
26,549	Poona Cantonment	Do. ...	1	2	...	...	...	1	...	...	...	...	...	C (?) How many were imported cases.
9,675	Junnar I. C. ...	Junnar ...	32	21	26	3	...	...	...	...	...	...	...	D
467	Shirali	Khed ...	10	1	...	...	...	...	...	...	...	...	...	D
192	Jalwad	Do. ...	...	1	...	...	...	...	...	...	...	...	...	D
1,686	Mahalunjah Ksb. ...	Do. ...	8	1	...	...	...	...	...	...	...	...	...	D
5,300	Manchar	Do. ...	13	4	...	...	...	...	...	...	...	...	...	D
428	Sukkar	Junnar ...	2	...	3	...	...	...	...	...	...	...	...	D
1,503	Grarde	Purandhar	...	...	1	...	...	...	...	...	...	...	...	D
1,897	Armi	Junnar ...	...	...	...	3	...	...	...	...	...	...	...	C
1,406	Hiware	Do. ...	...	...	...	1	...	...	...	...	...	...	...	D

POONA DISTRICT.

SECOND SERIES—CHART No. I—(*Concluded.*)

1910.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
885	Pimpalgaon Narayan	Junnar ...	...	...	...	— 2	— 1	...	...	..	...	...	...	B If local cases, may carry over, village of fair size.
740	Madhawa	Bhimtadi ...	...	...	...	— 2	...	...	...	...	...	...	...	C
450	Borkas	Haveli ...	...	...	...	— 2	...	...	...	...	...	...	...	C
120,543	Poona I. C. ...	Do. ...	...	...	...	— 4	— 1	...	...	...	...	— 1*	...	A If local cases, almost certain to carry over. * Imported in September, no local infection yet.
3,500	Awasari	Khed ...	...	...	...	...	— 1	...	...	...	...	...	...	C ?
5,856	Lonavla	Mawal ...	...	...	...	...	— 1	...	...	..	...	...	...	C ? Imported or local case.
768	Loni Kand ...	Haveli ...	...	...	...	...	...	— 1	...	...	...	...	...	C ?
2,322	Khandala	Mawal ...	...	...	...	...	...	...	— 1†	...	— 2‡	...	...	D † Found dead in train, so *not* local infection. ‡ Two cases in August were both imported.

POONA DISTRICT.

SECOND SERIES—CHART No. II.

1911.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
323	Khodit Kd. ...	Purandhar	...	— 15	...	...	...	...	...	...	...	...	...	D
1,097	Khodit Bk. ...	Do. ...	— 18	— 13	— 3	...	...	...	...	...	...	...	...	D
8,181	Baramati	Bhimthadi...	...	— 1	...	...	...	...	...	...	...	...	...	D
3,890	Talegaon Dabhade...	Mawal ...	...	— 1	...	...	...	...	...	...	— 9	— 40	— 36	D First case probably imported, re-infection in second season from Poona or Lonavla (q. v.) both imported.
933	Nimgaon	Khed ...	...	...	— 8	— 14	...	...	...	...	...	...	...	C
6,124	Saswad Ksb. ...	Purandhar	...	...	— 4	— 4	— 3	— 4	...	...	...	...	...	A Appeared to be almost certain to carry over, large village, but failed to do so.
170	Saswad Hamlet ...	Do. ...	...	...	— 1	— 3	...	...	...	...	...	...	...	D
1,378	Kedgaon	Bhimthadi...	...	...	—* 1	—* 1		...	...	...	...	...	...	D * Both these cases were imported and not local.
111,381	Poona City ...	Haveli ...	...	...	— 4	— 6	— 1	— 1	..	— 2	— 5	— 34	— 164	A Carried over. Local infection well established in February and March.
605	Waki Bk.	Khed ...	...	...	...	— 1	...	...	...	...	...	...	...	D
1,100	Nira Wagaja ...	Bhimthadi...	...	...	...	— 8	...	...	...	...	...	...	...	C
2,252	Ghota Wade ...	Haveli ...	...	...	...	— 1	...	...	...	..	...	...	...	D
613	Kondhawale ...	Do. ...	..	...	...	—† 1	— 1	...	...	...	...	...	...	D † Imported case in March.

POONA DISTRICT.

SECOND SERIES—CHART No. II—(*Concluded.*)

1911.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
6,680	Lonavla	Mawal ...	...	...	...	1	...	4	5	30	114	52	10	A Carried over, probably infected in March from Poona or Bombay (plague season of latter place).
268	Sangawade ...	Do. ...	...	...	...	1	...	...	...	...	...	...	...	D
3,062	Belhe	Junnar ...	...	...	...	...	1	...	...	...	...	...	...	C ?
719	Gangapur Bk. ...	Khed ...	8	...	...	...	1	...	...	...	...	...	...	C ? Imported or local cases.
5,720	Ghoda	Do. ...	...	...	...	...	1	...	...	...	...	...	...	C ?

POONA DISTRICT.

SECOND SERIES—CHART No. III.

1912.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
1,809	Dhamni	Khed ...	...	5	...	...	...	...	..	...	...	...	...	D
1,867	Waphagaon ...	Do. ...	...	4	...	..	...	...	...	..	...	...	...	D
1,018	Sirur Hamlet ...	Sirur ..	...	4	...	...	...	...	...	...	...	...	...	D
336	Sirasgaon	Do. ...	...	1	...	...	..	...	...	...	...	...	...	D
1,202	Gulunche	Purandhar	23	12	7	...	..	...	...	...	...	...	...	D
170	Saswad	Do. ...	...	1	...	...		...	...	...	...	...	...	D
8,181	Baramati	Bhimthadi..	...	1	...	...	...	...	...	...	...	...	...	D
1,100	Nira Waghaj ...	Do. ...	...	8	...	...	...	...	...	...	...	...	...	D
2,595	Bori Pardhi ...	Do. ...	...	3	...	...	...	...	...	...	...	...	...	D
487	Ambi	Mawal ...	...	1	7	...	..	...	...	...	...	...	...	D
319	Adhe	Do. ...	5	1	...	...	...	...	...	...	...	...	...	D
979	Chand Khed ...	Do. ...	...	3	4	2	...	...	...	...	...	...	...	D
1,078	Induri	Do. ...	8	1	...	...	..	...	...	...	...	...	...	D
833	Khedkale	Do. ...	...	1	...	...	...	...	...	...	..	...	...	D
219	Salumbre	Do. ...	...	2	...	...	...	...	...	...	...	...	...	D
951	Bhugaon	Haveli ...	2	3	...	...	...	...	...	...	...	...	...	D
1,596	Chinchwad ...	Do. ...	24	7	...	...	...	...	...	...	...	...	...	D
702	Donje	Do. ...	...	1	...	...	...	...	...	...	...	...	...	D
1,745	Dehu	Do. ..	18	9	...	...	...	...	...	...	...	...	...	D
2,930	Ghorapadi... ...	Do. ...	...	10	11	...	...	...	...	...	...	...	1	D

SECOND SERIES—CHART No. III—*(Continued.)*

1912.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
1,213	Lawale	Haveli ...	— / 2	— / 1	...	...	...	...	...	...	...	...	...	D
1,192	Khanapur	Do. ...	...	— / 3	— / 5	...	...	...	...	...	...	...	...	D
357	Talewadi	Do. ...	— / 10	— / 10	...	...	...	...	...	...	...	...	...	D
2,398	Wanawadi... ...	Do. ...	— / 2	— / 4	...	...	...	...	...	...	...	...	...	D
904	Almas	Do. ...	— / 2	— / 7	— / 1	...	...	...	...	..	...	...	...	D
111,381	Poona City ...	Do. ...	— / 208	— / 257	— / 122	— / 44	— / 1	...	...	— / 1	...	— / 3	— / 12	A Epidemic commenced in July so should not have been marked as certain to carry over. Subsequent history makes "carry over" doubtful.
9,162	Poona Suburban ...	Do. ...	— / 5	— / 3	...	— / 1	...	...	...	...	...	— / 1	..	C Have probably all imported from Poona City, etc.
26,549	Poona Cantt. ...	Do. ...	— / 2	— / 23	— / 6	— / 11	...	...	...	...	— / 1	— / 12	— / 27	B ? May or may not have carried over.
10,797	Kirkee Cantt. ...	Do. ..	— / 1	— / 2	...	— / 3	..	...	...	...	— / 14	— / 38	— / 54	B First five cases probably imported. Infected later on and then carried over.
4,246	Sirur	Sirur ...	...	...	— / 1	...	...	...	...	...	...	...	...	D
1,427	Chikhali	Haveli ...	...	...	— / 7	— / 3	...	...	...	...	...	...	...	C
407	Gorhe Kd. ...	Do. ...	...	...	— / 2	...	...	...	...	...	...	...	...	D
2,299	Nanded	Do. ...	...	...	— / 6	...	...	,,	...	...	...	..	...	D
922	Parmali	Do. ...	— / 1	...	— / 1	...	...	...	...	...	...	..	...	D
362	Sonapur	Do. ...	...	...	— / 2	...	...	...	...	...	...	...	...	D
2,378	Wanswadi	Do. ...	...	...	— / 3	— / 4	...	...	...	..	...	..	...	C
374	Akole	Do. ...	...	...	— / 1	...	...	...	...	...	...	...	...	D
1,507	Sangwi	Bhimthadi ..	...	...	— / 1	...	...	...	...	...	...	...	...	D
3,303	Khed	Khed ...	...	...	...	— / 1	...	...	...	...	...	...	...	C
88	Bedinge	Indapur ...	...	...	...	— / 1	...	...	...	...	...	...	...	D
527	Gulani	Khed ...	...	..	...	...	— / 1	...	...	...	..	...	...	D
1,274	Peth	Do. ...	...	...	...	...	— / 1	...	...	...	...	...	...	C
8,790	Junnar Town ...	Junnar ...	— / 1	...	...	...	— / 1	...	...	...	...	...	...	C

POONA DISTRICT.

THIRD SERIES—CHART No. I.

1913.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
...	Poona City ...	Haveli ...	30 / 23	41 / 34	45 / 39	33 / 29	2 / 2	...	2 / 1	... / 7	... / 62	.. / 345	.. / 608	A Epidemic commenced in September 1912. not severe so will probably carry over.
...	Poona Cantonment	Do. ...	20 / 14	16 / 9	27 / 12	9 / 6	2 / 2	...	...	...	..	... / 4	... / 11	D
10,190	Baramati	Bhimthadi...	62 / 38	21 / 21	4 / 4	...	...	...	...	...	...	...	... / 1	D
3,837	Gunawadi ...	Do. ...	...	2 / 2	...	...	...	..	...	...	...	...	...	D
1,903	Malad Tf. Baramati	Do. ...	1 / 1	1 / 1	...	...	...	...	...	...	...	...	...	D
1,141	Pashan	Haveli ...	...	6 / 3	...	2 / 2	...	...	...	...	...	...	...	C
1,774	Bhigwan	Indapur ...	...	9 / 5	1 / 1	...	..	...	...	...	...	...	...	D
2,282	Wanawadi ...	Haveli ...	...	...	2 / 1	4 / 3	...	...	..	...	...	... / 1	... / 20	C
2,593	Ghorpadi ...	Do. ...	..	...	...	9 / 6	7 / 6	...	...	...	...	... / 2	... / 10	B Infection well established March and April so should carry over.
1,223	Rawangaon ...	Bhimthadi...	...	...	...	8 / 7	...	...	...	...	...	..	...	C
725	Pimpalgaon ...	Khed ...	...	...	..	...	1 / 1	...	...	...	...	...	...	D (?) Imported or local cases.
1,144	Bahul	Do. ...	...	...	...	...	2 / 2	...	...	...	...	..	...	C (?) Imported or local cases.
278	Hiware Kd. ...	Junnar ...	...	...	...	...	1 / 1	...	...	..	...	...	...	D (?) Both small villages, ascertain if cases are local or imported.
86	Kale	Do. ...	...	...	...	...	...	1 / 1	...	...	..	...	...	D (?) Both small villages, ascertain if cases are local or imported.

AHMEDNAGAR DISTRICT.

THIRD SERIES—CHART No. II.

1913.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
...	Kharda	Jamkhed ...	13 / 0	16 / 0	2 / 15	1 / 1	...	...	...	...	...	...	...	C (?) Mistake in diagnosis or returns. No deaths in December and January ascertain population.
...	Loni Haveli ...	Do. ...	...	...	...	1 / 1	...	...	...	...	...	...	...	D
...	Ashtagaon ...	Parner ...	...	...	...	1 / 1	...	...	...	...	...	...	...	D
...	Devi Bhogari ...	Do. ...	...	...	...	...	3 / 2	...	...	...	...	...	...	B (?) Ascertain if local or imported. Knowledge of the population of these and other villages might assist in prognosis.
...	Pathardi	Shengaon ...	...	...	...	...	...	1 / 1	...	...	...	...	...	D (?) Ascertain if local or imported. Knowledge of the population of these and other villages might assist in prognosis.

SATARA DISTRICT.

THIRD SERIES—CHART No. III.

1913.

Pop.	Place.	Taluq.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Remarks.
...	Gowe	Satara ...	...	3 / – / 3	...	...	...	...	...	...	...	...	...	D
...	Karanje ...	Jawli ...	...	6 / – / 6	7 / – / 7	...	...	...	...	...	...	...	...	D
...	Kharashe ...	Do. ...	...	1 / – / 1	5 / – / 4	...	...	...	...	...	...	...	...	D
...	Ozare	Do. ...	10 / — / 9	2 / – / 1	...	...	...	...	...	...	...	...	...	D
...	Sarajpur ..	Do. ...	...	4 / – / 4	1 / – / 1	...	...	...	...	...	...	...	...	D
...	Ootare	Wai	21 / — / 13	7 / – / 4	3 / – / 1	...	...	...	...	...	...	...	...	D
...	Ozarde	Do.	19 / — / 15	3 / – / 2	...	...	...	...	...	...	...	.. / *1*	.. / *10*	D
...	Ane	Karad ...	...	2 / – / 1	5 / – / 5	...	...	...	...	...	...	...	...	D
...	Kolewadi ...	Do. ...	6 / — / 6	12 / — / 9	7 / – / 7	1 / – / 1	...	...	...	...	...	...	...	D
1,366	Kandur	Shirala ...	...	7 / – / 7	33 / — / 33	21 / — / 18	9 / – / 5	...	...	...	...	...	...	D
4,421	Mangale... ...	Do. ...	16 / — / 6	37 / — / 23	24 / — / 21	14 / — / 9	8 / – / 6	...	...	...	...	... / *1*	...	D
...	Ghoti Bk. ...	Khanapur ...	4 / – / 4	3 / – / 3	3 / – / 3	...	...	...	...	...	...	...	...	D
...	Ghoti Kd. ...	Do. ...	...	9 / – / 6	1 / – / 1	...	...	...	...	...	...	...	...	D
...	Lengare	Do. ...	12 / — / 7	11 / — / 11	2 / – / 2	...	...	...	...	...	...	...	...	D
...	Trimali	Khatav ...	17 / — / 10	7 / – / 7	...	...	...	...	...	...	...	...	...	D
18,665	Satara	Satara ...	...	4 / – / 3	5 / – / 5	8 / – / 8	...	...	...	...	... / *12*	... / *136*	... / *273*	A Should be almost certain to carry over.
5,333	Wai	Wai	...	4 / – / 3	5 / – / 5	10 / — / 7	8 / – / 6	...	...	... / *1*	... / *35*	... / *99*	... / *165*	B Started rather early but is a fair sized village.
8,574	Islampur ...	Valva ...	11 / — / 9	19 / — / 12	9 / – / 9 / 2	20 / — / 9	11 / — / 3	...	...	... / *2*	... / *29*	... / *69*	... / *86*	C (?) Started very early but is a large village.
...	Karanje	Satara ...	...	...	– / 2 / 1	...	...	...	...	...	...	... / *5*	... / *30*	D
...	Shahapur ...	Do. ...	...	...	– / 1 / 2	...	...	...	...	...	...	... / *6*	... / *26*	D
...	Nandgaon ...	Karad ...	...	...	– / 1	...	..	...	...	...	..	...	...	D
3,279	Chikurde ...	Valva ...	...	...	...	11 / — / 7 / 1	9 / – / 8	...	...	...	... / *6*	... / *25*	... / *27*	A Appears *very* likely to carry over.
601½	Eksal	Koregaon ...	...	...	...	– / 1	...	...	...	...	...	...	...	D
...	Dahigaon ..	Do. ...	...	...	...	...	2 / – / 2 / 4	...	...	...	...	...	...	C (?) Imported or local cases.
761	Palshi	Do. ...	...	...	..	...	– / 4	...	...	...	...	...	...	B May carry over *but* very small village.
...	Padale	Satara ...	...	...	...	...	...	1 / – / 1 / 1	...	...	...	...	... / *1*	D (?) Ascertain population and if cases are local or imported.
...	Mangalpur ...	Koregaon ...	...	...	..	...	...	– / 1	...	...	...	...	...	D
...	Kande	Shirala ...	...	...	...	...	...	...	20 / — / 8	... / *53*	... / *52*	... / *30*	...	A Certain to carry over —infected either end of plague season or early in off-season.

Note.—The plague figures for the villages mentioned in the third series of charts, which have subsequently come to hand, are entered above in italics. These show that in Poona District, plague was carried over only in Poona City; for Wanawadi, Chorpuri and Poona Cantonment are suburbs of Poona and were probably re-infected by importation. In Satara District, plague was carried over in Satara Town, Wai, Islampur, Chickurde and Kande. In the District of Ahmednagar and Sholapur there was no plague in the following season, at any rate before December.

RAT DESTRUCTION AND PLAGUE.

BY

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IN the annual report of the Bombay Bacteriological Laboratory for 1912, under the head of "Research Work," an account is given of the preparation of a phosphorus paste for poisoning rats and it is remarked that "the method of temporarily reducing the rat population by poisoning a large number of rats can be used with advantage as a means of combating the plague." Coming as this statement does, from such an authoritative source, I am encouraged to think that rat destruction by poison may be resuscitated from the position of undeserved oblivion to which it has receded of recent years, and may once more become an accepted weapon in our armoury; if this is so, it has seemed to me that it will not be inappropriate at this juncture to recall the attention of those interested, to the experience gained in the Punjab as regards this measure of rat poisoning, and the preparation of the poison. That this experience was an extensive one, may be gathered from the fact that from 1905 when the measure was introduced by me, to 1909, 45 tons of rat poison were actually used.

By 1905 it had become fairly clear that plague in man was secondary to, and dependent on, plague in the rat, and to us workers in the field, it appeared reasonable to suppose that, if the rat population could be reduced, a locality might be rendered more or less immune to plague, that importation of infection would be less likely to take root and develop into an epidemic, and that when an epidemic had begun it might be possible to stop its spread by clearing off most of the surrounding rat population in a small locality, or to cut off the infected rats from the healthy ones in a large town by establishing a rat free area between the infected and the healthy. Rat poisoning seemed the simplest method of achieving this object and it was on these not unreasonable surmises that rat poisoning operations were commenced in the Punjab.

That these operations reached the scale they did was due to several reasons; first there was the fact that in a large number of places, what we called endemic centres, plague seemingly reappeared annually without any fresh importation, these places had to be attacked; again, plague was seen to reappear in the autumn in places infected late in the spring without fresh importation, and we included all such places infected during the latter part of the annual visitation in our programme; but it became obvious that plague infection was often imported in the spring and early summer which showed no sign till the following autumn and consequently we were bound to attack not only the late spring infections but all those neighbouring places that might have received infection from them and so it came about that, in the hope of being as complete as possible, rat poisoning was undertaken wholesale over very large areas; the second point was that we very quickly discovered that the effect produced, though great at first, was only temporary in its reducing effect and consequently we tried to attack each place two or three times during the plague active season, moreover when plague appeared we not only poisoned rats in that locality but in as many surrounding villages as we could to lessen the danger of importation causing an epidemic. In 1906-07, 15 tons of poison were used and 8,650 villages and 70 municipal towns were attacked in this way. It is not possible here to even summarise the effects produced, those interested may be referred to the numbers of reports and reviews written at various times, it will be sufficient to say that rat poisoning was found often to be very successful is achieving the object aimed at, cutting short epidemics and so on; again it often failed, as it was imperfectly carried out and villages were often infected and badly attacked with plague after the effect of the rat poisoning had passed away; it was found however that a commencing epidemic was frequently aborted, that villages that had been ratted were less liable to infection for some time and, if infected, suffered less severely than those where no rat poisoning had been done; where poisoning was repeated, the effect was more marked. I cannot refrain from quoting the following figures taken

from two contiguous areas in a year when plague was universally distributed and which previous experience had shown to be equally susceptible to infection.

	Ratted area.	Not ratted.
Number of villages	154	86
Number of villages in which more than 9 deaths occurred	30	84
Number in which less than 10 deaths occurred ...	49	2
Remained free	75	0

The incidence in the two areas was 5·18% and 1·4% respectively; the effect of repeated poisoning campaigns on plague mortality is also well shown.

Areas, no poisoning	5%
Areas, poisoning once or twice	3%
Areas, poisoning three times	1%

In the report on the operations of 1906-07 it was calculated by Captain Davys that, after making every allowance for error, at least 40,000 lives must have been saved by the rat poisoning campaign. Rat poisoning is simplicity itself and quite without danger; the baits are prepared in the day and are laid in the afternoon and evening in such places, behind boxes against the wall, on the top of the walls supporting the roof, where other animals or children cannot get at them; the baits not taken during the night are collected next morning; the mere fact that so much poisoning was done and that no accident happened save the deaths of a few fowls and crows shows that the danger is *nil*. Three coolies and a compounder to supervise, can easily prepare and lay ten or twelve thousand baits in a day, 20 to 40 baits for each of 400 houses representing a population of 2,000 to 2,500, and a sub-assistant surgeon can supervise and control 3 or 4 such gangs so that large areas can be treated in a single day. It was evident however that operations on this scale, frequently repeated, could not be carried on indefinitely and traps were gradually introduced in the attempt to produce a more permanent effect or to maintain the sudden reduction in the rat population brought about by rat poisoning. Rat trapping was extensively employed and still continues on modified lines (*see* Punjab Plague Manual). Rat traps were supplied to villages and towns with the object of keeping up a permanent reduction of rats throughout the plague season in uninfected places exposed to infection and of concentrating them on infected spots as soon as plague appeared; these operations also were attended with a fair measure of success. The operations for the protection of Delhi from plague at the time of the Royal Durbar included trapping and 250,000 rats were removed from the city alone in five months; in fourteen places near Delhi where rat mortality had begun, rat destruction was at once instituted and no human plague appeared. Rat destruction however fell upon evil days; the reasons were many; our most extensive campaign took place during our worst plague epidemic when over 600,000 lives were lost and many concluded from this that, even if our operations had not actually caused the epidemic it had done no good; calculations were made of the expense incurred in this apparently useless measure; people made mathematical calculations in their offices of the wonderful breeding power of the rat and, aghast at the figures they produced said that rat destruction was futile; others proclaimed that nothing but the reconstruction of Indian villages and towns on rat proof lines and the protection of the food-supply could be of any avail, a matter of generations of sanitary progress and a useless platitude to us at grips with a devastating panorama, as much good as to tell a man whose house is burning that the remedy for his trouble is to construct a house of incombustible materials.

With ten years or more plague service to my credit or perhaps rather to my discredit as I have not abolished plague in the Punjab, I am absolutely convinced that much more life has been saved by rat destruction in my province than by all other measures put together. Not that I would for an instant discount the value of such admirable measures as evacuation and inoculation; both these measures have been carried out as far as was humanly possible, but neither of them are generally applicable and taken advantage of until plague is rampant, and rarely can an epidemic be cut short by these means. Rat destruction, on the other hand, can be carried out almost any where even in the absence of plague because it causes no trouble and does not disturb the people.

The question is when can rat destruction be most profitably used? When plague is just beginning and a case or two of plague has occurred and few dead rats been found, what is to be done to stop infection spreading? Evacuation is usually impossible and inoculation only accepted by a few, there is indeed only one possible way of attempting it and that is by rat destruction in the surrounding area. Knowing that plague infection is carried over from one season to another, especially in places suffering an incomplete epidemic towards the end of the spring, our only chance of preventing or materially mitigating the second epidemic is by rat destruction. An uninfected locality in dangerous proximity to, or surrounded by,

infected places can often be successfully protected by rat destruction. In a report to my Government in 1905, I said, "the idea that with the seasonal subsidence of plague, the emergency is, for the time at an end, must be killed and another substituted, namely, that our great hope lies in a campaign during the free season and in the earliest stages of the epidemic before it has passed beyond control." This I believe is now beginning to be recognised as the only sound basis for an effective plague policy, and we may expect action to be directed on more definite lines instead of being confined to the application or measures such as evacuation and inoculation when plague has passed beyond control.

Rat destruction, therefore, is the measure to be applied generally for the prevention of plague and for cutting short epidemics which have just begun and it is the only measure that is generally accepted when plague is apparently absent or only slight for it is simple and gives practically no trouble to the people; it is therefore a method of combating plague of extreme importance and should be resorted to much more than it is. When epidemics have passed beyond control, inoculation and evacuation come into their own and are of the greatest value for saving a considerable number of lives.

Of methods of rat destruction, poisoning is by far the most simple and rapid for in a single night, the rat population can be very severely dealt with, and properly carried out a reduction of 80% should be effected. Trapping is slower and is most appropriately used in conjunction with poisoning, to still further reduce the number of rats and keep it from increasing again. Traps are particularly useful in towns where continued supervision can be employed and if a supply is kept ready, traps can often be placed in every room of the houses surrounding the infected spot with excellent result; poisoning in addition is to be recommended. The method of smoking out rats that has been recently introduced is, I believe, very effectual, but has the disadvantage of being troublesome to the people as their goods and chattels have to be cleared out of rooms, a big business in the case of bunniahs' shops and such like places; it requires therefore the close supervision of a tactful and energetic officer.

After a good deal of experimental works we evolved a formula for a rat poison which has proved very successful and established a poison factory to turn it out in large quantity.

One tin of this paste containing some twelve ounces costs ten annas or so, and is sufficient for 1,500 baits each capable of killing a full grown rat. The danger of ignition is referred to by the Director of the Parel Laboratory, this was one of our difficulties and was got over by ensuring very fine division of the phosphorus and by reducing the phosphorus content to below 3%. The method of mixing the poison with *atta* and *gúr* and rolling the mixture into balls is infinitely better than spreading it on *chapaties* or bread.

The phosphorus is first dissolved in carbon bisulphide and this is then added to warm *ghí;* this oily solution is then added to and incorporated with a stiff paste of *atta*, sugar and water in a special mixing machine. Flavouring substances are also added to make the baits attractive; the comparative attractiveness of these was determined experimentally by baiting traps with dough scented with different essences, plain and mixed, and placing these traps on heaps of grain in grain godowns so that the rat travelled over food-stuff to get to the traps. We shall be very glad to give all details of this poison manufacture to any one who wishes to make it or to supply the poison.

There are doubtless difficulties in the way of successful rat destruction, and it is often impossible to carry it out thoroughly and failure results, but gentlemen, if we are to stop on account of difficulties we may as well wash our hands of the whole business and do nothing, for rat destruction is by far the simplest and easiest measure to carry through. It is practically our only hope of preventing an expected, or aborting a commencing, epidemic and should be much more resorted to than it is. When epidemics are raging beyond control we fall back on our second line of defence which the people may then be ready to accept, inoculation and evacuation; general sanitary measures must also be constantly taught and encouraged, so that rat infestation may be lessened, and the rat in time evicted from the dwelling of man.

THE USE AND ADVANTAGES OF HYDROCYANIC ACID GAS AS A DISINFECTANT FOR PLAGUE-INFECTED HOUSES AND SHIPS.

BY

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THE words disinfection and disinfectant have an indefinite meaning to many medical men. This statement can be verified if pains are taken to study the methods of disinfection they practice. Before the germ theory was accepted the term disinfection was used to include the destruction of infectious matter and the removal of any noxious odours to which such matter gives rise.

Men generally have an instinctive repugnance for bad smells and from the earliest times have sought to mask them by the use of aromatic substances. Many religious ceremonies, the burning of incense for example, may perhaps have originated in this way. We learn at least from Homer that sulphur was used in religious ceremonies and according to Plutarch, during the plague at Athens, Acron stayed the spread of the epidemic by lighting fires in the middle of the public places and in the streets where deaths had occurred.

These religious or semi-religious ceremonies were closely imitated in India so recently as during the first outbreak of plague in Bombay in 1896-97. Sulphur fumigations were at this period carried out in the streets and houses. Lockets containing camphor and eucalyptus and other aromatic substances were worn round the neck to ward off infection. Tons of carbolic acid and other chemical disinfectant were poured into the sewers. In certain instances drain pipes were taken down from the houses and steeped in hot water. Chloride of lime, creosote and carbolic powders were strewn about without system. White-washing was superadded to the chemical disinfection. At one time a system was in vogue by which houses situated on the line which plague was expected to follow were white-washed in advance, this measure in some cases being confined to the outside of the houses. Many of these methods of disinfection have now been abandoned but chemical disinfection on a slightly modified and curtailed plan is still practised.

The methods of disinfection we have referred to above were not adopted without reason; they were based on the early work of biologists and bacteriologists. Pasteur with others showed that fermentation, putrefaction and decay were due to the action of living organisms which can float in the air. Lister, perceiving the connection between suppuration and fermentation, first used disinfectants to prevent suppuration, he sprayed the disinfectants in the air during the course of surgical operations. Surgeons have long ago abandoned these early and crude methods for preventing suppuration as research showed that contaminated hands and instruments which had come into contact with pus and had not been properly cleansed were more dangerous than the air which surrounded the surgeon and patient during an operation.

Public health officers, unlike their confréres the surgeons, have not always profited by the knowledge gained by bacteriological research.

For many years bacteria have been divided into two groups, saprophytic bacteria and pathogenic bacteria. The members of the first group live for the most part on dead organic matter, while the latter produce disease and are generally found on or in living creatures. The sphere of influence of each of these groups of organisms is always restricted. Saprophytic bacteria do not thrive on living matter while on the other hand pathogenic organisms, if not protected from saprophytes, cannot live on dead material. This struggle for existence between the two groups of organ-

isms, which is continuously and everywhere at work in nature, may be regarded as one of the most important of all disinfecting agencies which operate in the direction of destroying pathogenic bacteria. It is admirably illustrated in the changes which take place in the body of an animal which has died of plague. Immediately after death the whole body of the animal is found to be swarming with plague bacilli; a few hours later, the saprophytic bacteria make their appearance when the temperature is favourable for their development, and multiplying enormously, cause the rapid dissolution and disappearance of the plague bacilli. In a warm climate it is scarcely possible to discover a plague bacillus in the body of a small animal such as a rat forty-eight hours after its death from plague.

Another disinfecting process often overlooked by sanitarians but which is a powerful and natural process applicable to the large majority of pathogenic bacteria, is that effected by drying.

The competition of saprophytic bacteria and the devitalizing effect of desiccation ensures the destruction of non-sporing pathogenic organisms such as plague within a short time after their escape from the body of an infected animal, provided that the temperature is favourable for the effective action of these natural disinfecting processes. The Plague Research Commission have shown that highly susceptible animals allowed to run about on floors grossly contaminated with plague cultures twenty-four hours previously did not become infected in a climate like that of Bombay. The natural proces of disinfection described above had effectually acted to render the floors harmless.

The Commission also showed that plague bacilli found shelter from these natural destructive forces, as well as from chemical disinfectants, in the bodies of infected rat fleas, for, when infected rooms had been washed out with even so powerful a bactericidal solution as perchloride of mercury of a strength of 1 to 750, they still remained infective for susceptible animals like guinea-pigs. They showed that infection was acquired by the animals from rat fleas which were not killed by the disinfectant and which effectually protected the plague bacilli within their bodies from the action of saprophytic bacteria, desiccation and chemical disinfectants.

The Commission have further shown that, in bubonic plague at least, the plague bacilli are removed from the blood of rats in the acute stage of the disease by fleas which transfer the bacilli to fresh animals; the disease is in fact only maintained by the transference of the germs from rats to fleas and from fleas to rats.

The essential point then to be aimed at in plague disinfection is the destruction of rats and rat fleas which may harbour the plague germs for considerable periods. Having killed these creatures the natural disinfecting process referred to above brings about the ultimate destruction of the plague bacilli. The present day methods of combating plague are based on this finding. Rats are caught in traps or are destroyed by poison; fleas are killed by the use of pulicidal solutions such as oily emulsions. These methods, however, are clumsy and at best are not very efficient. A poison is required which will kill both rats and fleas and which can penetrate to the inaccessible places where these creatures find shelter. A poison that will satisfactorily fulfil these conditions must be of a gaseous nature. It must be capable of diffusing or being blown into rat holes or burrows and into the interstices of the roofs and among the lumber which is stored in Indian houses where rats and fleas abound.

Experiments have been carried out at the Bombay Bacteriological Laboratory for some years with the object of discovering a gas which will fulfil the requirements mentioned above. Sulphur dioxide, Carbon monoxide, Carbon disulphide, petrol vapour, Formaldehyde gas and latterly Hydrocyanic acid gas have all been experimented with. Of these gases only two have been employed on a large scale for the disinfection of plague-infected houses and ships in Europe. Sulphur dioxide gas produced in the Clayton Gas machine has been most popular in England while carbon monoxide generated in Leybold's apparatus has been selected in Germany. We have made many experiments with these gases and submitted reports on the matter to Government from time to time. We may sum up the results of these experiments briefly by stating that we found carbon monoxide quite ineffective in killing fleas. The gas was dangerous to work with because it has no smell, it could not be seen and its presence could not be detected by any simple chemical test. It however readily killed rats and was cheaply produced, but its production was associated with the danger of fire.

Sulphur dioxide gas was very lethal for rats and when in considerable concentration killed fleas also. The great drawback to the use of this gas is that it is readily absorbed by many articles of commerce and when applied to the disinfection of a loaded barge or filled godown the gas has to be produced in such enormous quantities to be effective that the cost is very considerable. The gas also has a destructive action on metals, fabrics and grain; the latter commodity is spoiled for culinary purposes and does not germinate well after exposure to the fumes. Recently an added danger has been discovered in the risk of fire on ships which are furnished with cold storage rooms which are insulated with charcoal. It is now the custom

for sanitary authorities when disinfecting a ship with this gas to leave untouched the engine room and the cold storage plant.

We have found that hydrocyanic acid gas has many advantages over both Sulphur dioxide and Carbon monoxide and the other gases we have experimented with. One of us in Scientific Memoir No. 38 and in a paper read at the last All-India Sanitary Conference in Madras has given an account of some preliminary experiments with the gas using it on a comparatively small scale. These experiments showed that hydrocyanic acid gas is extremely lethal both for rats and fleas even in very low concentrations and its action is more rapid and certain than sulphur dioxide. The gas being slightly lighter than the air does not diffuse easily in a downward direction, as for example, into rat burrows but by blowing the gas into a room through a number of tubes and allowing time for diffusion it penetrates in sufficient quantity to be lethal to fleas and rats in almost all situations. The tests as to its action on foodstuffs and grain showed that these were not rendered poisonous nor was the germinating power of grain impaired. The cost of materials for generating the gas was low, being about 6 annas per 1,000 cubic feet to be disinfected, using $\frac{3}{4}$ oz. of potassium cyanide per 100 c.ft., a quantity we found to be sufficient for the destruction of rats and fleas.

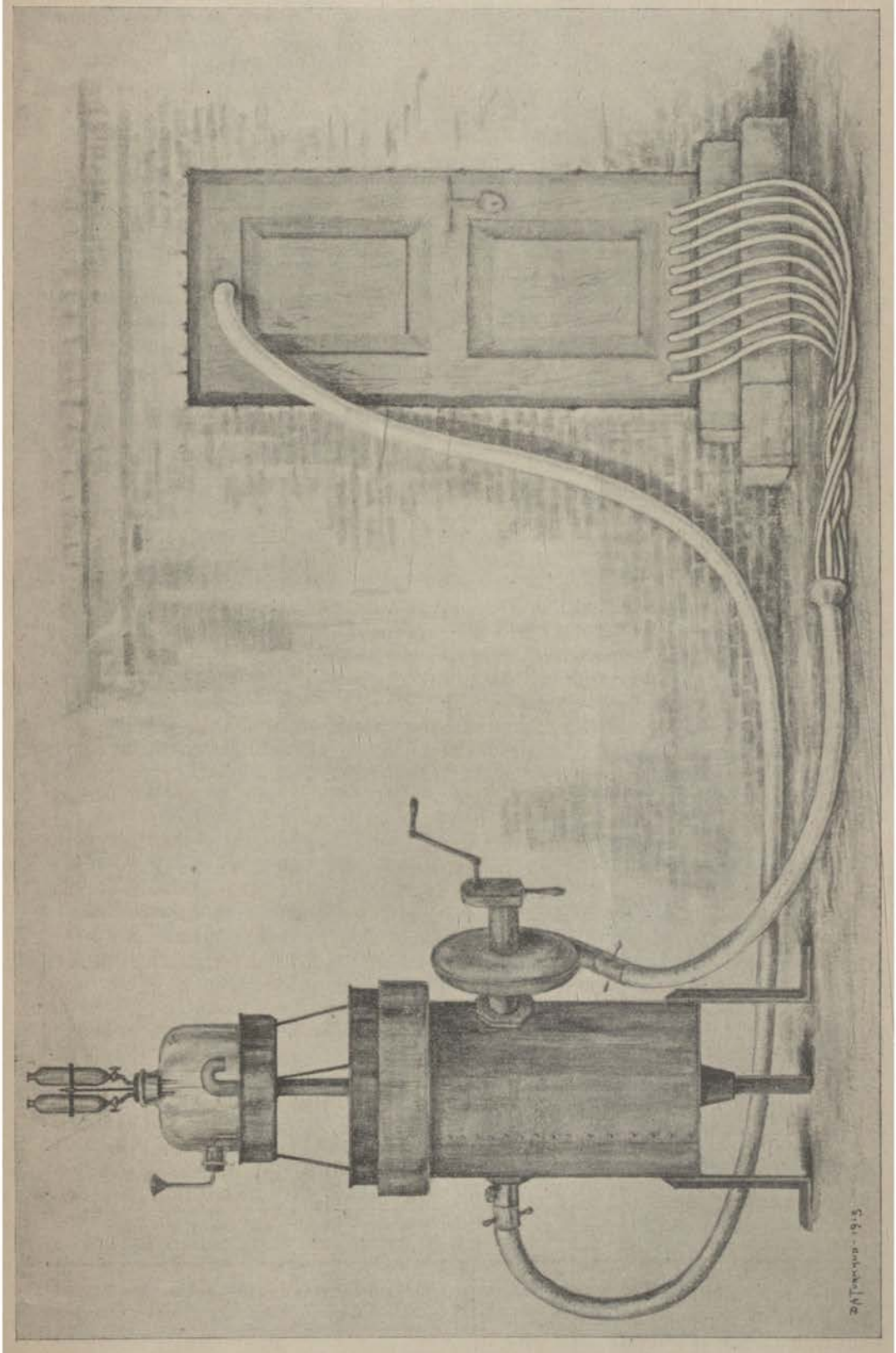
The success of these preliminary experiments led us to conduct further experiments with the object of determining (*a*) the proper concentration of the gas to be used in empty and filled rooms and holes; (*b*) the best methods for generating and applying the gas. The present experiments may be divided into three series. The first two series were carried out in a small godown of 346 cubic feet capacity which could be made fairly air-tight; the third series were carried out on a barge which had two holds each of 6,000 cubic feet capacity. In the first series of experiments, the hydrocyanic acid gas was generated by acting on lumps of potassium cyanide with sulphuric acid and water, in the last two series the gas was more satisfactorily generated by mixing together solutions of sulphuric acid and potassium cyanide of the strength of 50%. In some of the experiments of the first series, with the object of simplifying the method of production and curtailing expenditure, the gas was generated in the godown itself (no special apparatus being used to diffuse the gas) but in the majority of experiments a special apparatus has been employed which may be described here.

The apparatus consists of a leaden vessel placed over an iron chamber. To the side of this chamber, which may be called the mixing chamber a fan is attached which can aspirate the gas from the chamber and blow it along a rubber pipe to the room which has to be fumigated. The leaden vessel on the top of the mixing chamber is covered with a glass bell-jar which sits on a water seal so that the leaden vessel when covered with the jar forms another chamber in which the hydrocyanic acid gas is generated. The upper generating chamber communicates with the lower mixing chamber by a leaden pipe which projects into the former chamber above the level of any acid contained in the leaden vessel. An opening on the side of the mixing chamber, opposite to the fan allows the air to be sucked into the chamber when the fan is driven, but, when this opening is connected by a rubber tube with the room which is being disinfected the mixed gases of the room are drawn along the tube to the mixing chamber where more hydrocyanic acid gas is added from the generating chamber above and the mixed gases are again blown into the room. The gas is thus circulated through the machine to the room and back again to the machine. In order to secure better diffusion a rose is attached to the end of the three-inch rubber tube which leads from the machine to the room. To the rose 9 one-inch rubber tubes are adjusted and these one-inch tubes can be placed in different parts of the room, into rat holes, behind cupboards, amongst lumber and in other suitable positions to obtain thorough diffusion of the gas throughout the room.

In the first experiments with this apparatus, the gas was generated by placing lumps of potassium cyanide with some water in the leaden vessel and when the bell-jar had been adjusted strong sulphuric acid was added from a thistle funnel introduced through a hole in the side of the bell-jar. In our second and third series of experiments we improved on this method of generating the gas by mixing together solutions of potassium cyanide and sulphuric acid of 50% strength. The two solutions were placed in two large separator funnels which led through a rubber bung at the top of the bell-jar; by means of stop-cocks the two solutions were allowed to flow at any desired rates into the lead vessels below. When the two solutions mixed hydrocyanic acid gas was rapidly evolved. The rate of production of the gas could be delicately regulated by the stop-cocks and by observing the evolution of the gas through the glass bell-jar. We were able thus, at the beginning of fumigation to produce large quantities of gas by running in the two solutions rapidly into the leaden vessel, and, later, by running the two solutions less rapidly, we could keep up the concentration of the gas in the room which was being disinfected.

A delicate chemical test for hydrocyanic acid gas consists of a paste prepared by mixing in a dry mortar caustic soda and ferrous sulphate. This is applied to a glass rod and the rod is exposed to the gas for a definite period. A few drops of

hydrochloric acid are then added to the paste on the rod and the rod is stirred up in some water in a test tube. The development of a prussian blue colour indicates the presence of hydrocyanic acid gas. The depth of the colour gives a rough idea of the concentration of the hydrocyanic acid gas if the paste is exposed for a constant period. The smell of the gas and this delicate test for its presence enabled us to use it with marked success in killing rats and their fleas without danger to ourselves



or our assistants. In all the experiments except the last two of the first series, *i.e.*, in experiments 1, 2, 3, 4, & 5 as well as in the last experiment of the second series (Expt. 13) the small godown used was filled with bags containing rice which were so closely packed together that there was only room to open and close the door. In these experiments, rats were allowed to run free in the godown and in some of them they had been allowed to live for some days among the rice bags before the

disinfection was carried out. It is interesting to note that the rats did not burrow into the bags but lived in the spaces between them making only small holes in the bags sufficient to obtain food. In experiments 6 & 7 of the first series rice was spread on the floor of the godown to the depth of 3 or 4 inches with the object of testing whether the fleas would bury themselves deeply enough into the rice to escape destruction by the gas. We found that the fleas did not penetrate far enough into the rice to avoid the lethal effect of the gas.

In the third series of experiments which were conducted on a much larger scale than those of the first two series the disinfection of a space of 12,000 cubic feet was attempted. The barge which was used in these experiments was built of iron. Each hold had a rough floor made of planks laid over the ribs of the vessel so that there was a space of about 9 inches to 1 foot between the outer iron plates and the wooden floor. The hatches were very large and in our experiments, were simply covered with sail-cloth and tarpaulins which were weighted down around the edge of the hatches. The distributing and return pipes from the generating machine were led under the canvas into the holds. The holds were by no means air-tight but in spite of this no appreciable odour of hydrocyanic acid gas was observed by us while walking about on the barge during the course of the experiments. The generating machine was worked from the wharf to which the barge was moored. The holds of the barge were empty and rats were placed in cages in different parts both above and below the wooden floors and in some experiments they were allowed to run freely in the hold and to take such shelter as was available beneath the planks. The details of our experiments are given in the form of an appendix to this paper; they have led us to the following conclusions:—

(1) Hydrocyanic acid gas is an effective disinfectant for plague not because it has any direct action on plague bacilli, but because it kills rats and fleas. The fact that rats do not generally live in grain bags but in the spaces between them and that fleas do not bury themselves in grain to a greater depth than the gas can penetrate ensures that they are readily accessible to the action of the gas.

(2) The gas can easily be generated, distributed and diffused through rooms, godowns, and the holds of ships by the apparatus we have devised.

(3) Owing to its characteristic odour and to the existence of a simple and delicate chemical test for its presence, this very poisonous gas can be used with safety by persons who exercise a moderate amount of caution.

(4) This gas does not injure the most delicate fabrics or metals and does not render food unfit for consumption; grain will germinate after exposure to the gas.

(5) No light or heat is required for the production of the gas so that the danger of fire or explosion is non-existent.

(6) The cost of chemicals for generating the gas is small; twelve thousand cubic feet can be treated for about three rupees and four annas.

(7) The generating apparatus we have used is fairly portable. A single machine would suffice for the disinfection of an ordinary Indian dwelling but a battery of five or six machines would be required for the disinfection of a large ship or godown.

(8) The gas being slightly lighter than air can be easily removed from rooms, holds, etc., by ordinary ventilation.

(9) The quantity of gas required for efficient disinfection will depend on the air-tightness of the room to be treated, the time the gas is allowed to act, the thoroughness of the distribution and diffusion of the gas, as well as on the cubic capacity of room and whether it is full or empty.

(10) In general we have found that from $\frac{1}{2}$ to $\frac{3}{4}$ of an ounce of Potassium cyanide per 100 cubic feet of space to be treated should be used. The gas should be allowed to act for about four hours. In small rooms which can be fairly tightly closed half an ounce of Potassium cyanide per 100 cubic feet will suffice and the period of exposure can be reduced to one hour. If larger spaces are treated, such as godowns and holds, especially if these are full of merchandise, $\frac{3}{4}$ of an ounce of Potassium cyanide will be required and the gas should be allowed to act for four hours.

(11) The accompanying table compares and contrasts the advantages and disadvantages of Hydrocyanic acid, Sulphur dioxide and Carbon monoxide gas as disinfectants for plague.

	Hydrocyanic Acid (HCN).	Sulphur Dioxide (SO_2).	Carbon Monoxide (CO).
Effect on rats ..	Very lethal in small concentration (·15%), after short exposure.	Lethal in strong concentration 4% after a more prolonged exposure.	Lethal especially at lower level of room.
Effect on fleas ..	Ditto. ..	Lethal only on prolonged exposure to strong concentration. Effect less than on rats.	No action on fleas.

	Hydrocyanic Acid (HCN).	Sulphur Dioxide (SO_2).	Carbon Monoxide (CO).
Effect on grain ..	Does not prevent germination or render poisonous.	Spoils grain. Prevents germination.	No effect on grain.
Effect on metals and fabrics.	No destructive action ..	Spoils metal. Bleaches cloth.	No destructive action.
Cost of chemicals only per 1,000 cub. feet to be disinfected.	Six annas	Rs. 6-8-0 ..	Two annas.
Dangers ..	(*a*) Highly poisonous to man but on account of lightness easily got rid of from the holds of ships. Detectable by smell which gives warning; also by delicate chemical tests. (*b*) No danger from fire.	(*a*) Irritant. Smell gives warning and no one is likely to remain in atmosphere containing strong concentration long enough to be seriously affected. (*b*) Fire required to produce gas. Gas is also capable of setting fire to ship from its action on refrigerating apparatus.	(*a*) Poisonous, remains at lowest levels and difficult to blow out. No indication by smell. (*b*) Fire required in production no other fire danger.
Special advantages	Cheapness. Efficiency on both rats and fleas. Rapid action. Generation of gas easily controlled.	Less poisonous	Cheapness.
Special disadvantages.	Poisonous effect. ..	Danger from fire. Destructive action on certain cargoes.	No effect on fleas. Poisonous effect on man. Not detectable by smell.

DETAILS OF EXPERIMENTS.

First Series.

Gas generated by the action of sulphuric acid and water on lumps of potassium cyanide. Experiments carried out in small godowns with a capacity of 346 cubic feet. Experiments 1 to 5, godowns filled with rice bags; experiments 6 & 7 rice spread on the floor to a depth of three or four inches.

Experiment No. 1.—20 rats were introduced into the godown on the evening before the experiment.

4 ounces of KCN was used and the gas pumped in for 45 minutes.

The godown was entered on the following day and all rats were found dead between the bags. Fleas which were buried in muslin bags at various levels in the rice bags were found alive at 3″ below the surface of the grain showing that the gas had not penetrated to this depth, although they had been killed nearer the surface.

Samples of the rice from this godown were sent to the Agricultural Chemist to the Government of Bombay, who reported that :—

(1) No HCN gas was absorbed by the rice sent to him.
(2) The food value of the rice had not been affected.
(3) The unhusked rice germinated equally well after treatment.

These results confirmed those found at the laboratory.

Experiment No. 2.—The same godown was used and the same amount of KCN as in Expt. No. 1, but the gas was circulated through the machine by means of an exit pipe from the godown by which it was sucked out and pumped back again. 20 rats were put in the godown 10 days before the experiment and 20 more, 3 days later. From the condition of their bodies after fumigation it was obvious that 37 rats were alive immediately before the experiment. All were killed by the gas. The fleas placed in muslin bags as in Expt. No. 1 were killed at short distances below the surface but not at 3″ or deeper.

Experiment No. 3.—Conditions as in Expt. No. 2, only 5 ozs. of KCN were used (= about $1\frac{1}{2}$ ozs. per 100 cubic feet).

The machine was worked for 35 minutes.

All 30 rats introduced into godown were killed. Fleas had been introduced below the surface of the rice in glass tubes covered at the ends by gauze. These escaped destruction even at 2″ below the surface.

Experiment No. 4.—The gas was produced inside the room without use of the pumping machine. The amount of KCN used was 3 ozs. (slightly less than 1 oz.

per 100 cubic feet); 18 out of 20 rats were killed. Fleas buried in the grain even close to the surface escaped the lethal action of the gas.

Experiment No. 5.—Generation as in No. 4, only 5 ozs. KCN were used (about 1½ ozs. per 100 cubic feet). Experiment commenced at 8 A.M., door of godown opened at 3 P.M. Godown inspected on following morning.

30 rats (all) found dead. Fleas buried at 1″ and 2″ in the grain were killed. Fleas had been buried as a control in a bag of rice not exposed to fumigation for the same length of time as in the experimental godown. One of these was found living.

Experiments Nos. 6 *&* 7.—The following experiments were undertaken to observe the action of the gas on fleas set free on the top of rice in bulk in the godown:—

The floor of the godown was covered with rice to a depth of 3″ to 4″. It was thought that fleas might burrow into rice to some depth and so escape the action of the gas.

Two godowns were taken and the rice spread over the floors of both. The same number of fleas were set free in each. One godown was fumigated and the other used for control observations. The method used to collect the fleas after the experiment was to introduce a guinea-pig which had been freed from fleas to act as a flea-trap, the guinea-pig with any captured fleas was then chloroformed; the fleas were removed from the guinea-pig and counted.

Experiment No. 6.—170 fleas were introduced into the godown at 8-30 A.M.

One hour later one of the godowns was fumigated, 5 ozs. of KCN (1½ ozs. per 100 cubic feet) being used. Both godowns were opened at 12 noon.

At 1 P.M., two guinea-pigs (freed from fleas) were placed in each room and allowed to remain till 10-30 A.M. next day. They were then chloroformed and examined.

From the control godown which had not been fumigated 8 fleas were recovered.

From the fumigated godown no fleas were recovered. As an additional experiment two gauze bags containing fleas had been buried 1″ deep in the rice. All these fleas were found dead at 1 P.M. on the day the gas was introduced, while fleas placed under the same conditions in the control godown (unfumigated) were found alive at the same time. Again, therefore, penetration of the gas to a depth of 1″ had occurred.

Experiment No. 7.—This is a repetition of Expt. No. 6, only 300 fleas were put in each godown. They were introduced at 9-15 A.M. One godown was fumigated at 11-30 A.M. The rooms were opened at 1 P.M. Four guinea-pigs freed from fleas were introduced into each godown at 2 P.M. They were examined at 11-30 next morning and again placed in the godown for 2 hours more and again inspected.

Thirty-two fleas were recovered from the control non-fumigated godown and none from that which had been fumigated.

Second Series.

Gas generated by mixing solutions of equal parts of strong Commercial Sulphuric acid and water with a 50% solution of potassium cyanide in water. Experiments carried out in a small godown with a capacity of 346 cubic feet. In experiments 8 to 12 the godown was empty but in experiment 13 it was filled with bags of rice.

Experiment No. 8.—12 rats in cages in godown.
60 fleas in test tubes.
KCN solution used = 1 oz. KCN per 100 cubic feet.
Generation occupied 15 minutes.
Gas circulated for 10 minutes more.
Gas blown out for 20 minutes.
Godown opened one hour from start.
All rats and fleas dead.

Experiment No. 9.—Arrangement as in No. 1.
KCN solution used = ½ oz. KCN per 100 cubic feet.
Generation occupied 4 minutes.
Circulation by fan continued for 11 minutes more.
Blowing out by fan for 10 minutes.
Godown opened at ½ hour from start.
All fleas dead.
11 rats dead, 1 dying.

Experiment No. 10.—Conditions and quantities as in Expt. No. 2.
Generation occupied 4 minutes.
Circulation continued for 10 minutes more.
Blowing out continued for 7 minutes.
Godown opened and entered at 24 minutes from start.
All rats and fleas dead.

Experiment No. 11.—Conditions as in Expt. No. 2, but KCN solution used was only equal to ¼ oz. of KCN per 100 cubic feet.

Generation occupied two minutes.
Circulation was continued for 6 minutes more.
Blowing out was carried on for 5 more minutes.
Godown opened at 15 minutes from start and entered two minutes later.
All fleas were dead.
4 rats dead and 8 rats sick.

Experiment No. 12.—Conditions as in Expt. No. 4.
Generation occupied ½ minute.
Circulation continued for 30 minutes.
Blowing out carried on for 7 minutes.
Godown opened and entered at 40 minutes from start.
All fleas dead.
11 rats dead, 1 rat sick.

These experiments show that ½ oz. KCN per 100 cubic feet is an effective quantity in a small empty room which could be made fairly air-tight; the time allowed for its action being about half an hour.

Experiment No. 13.—Godown used, 346 cubic feet.
56 bags of rice were introduced, nearly filling the godown.
20 rats were let loose among the bags two days before the experiment.
The following tests for the action of the gas on fleas were prepared :—

(1) Two muslin bags each containing 10 fleas placed outside the grain bags.
(2) One muslin bag containing 10 fleas placed between the bag and the surface of the rice.
(3) One muslin bag containing 10 fleas placed within the bag and 1″ below the surface of rice.
(4) One muslin bag containing 10 fleas placed within the bag and 2″ below the surface of rice.
(5) One muslin bag containing 10 fleas placed within the bag and 3″ below the surface of rice.
(6) One muslin bag containing 10 fleas placed within the bag and 6″ below the surface of rice.

4 test tubes open at the top containing 10 fleas each were placed vertically in the godown.
2 test tubes covered with gauze containing 10 fleas each were placed horizontally in the godown.
35 minutes after the commencement of the experiment 40 fleas in muslin bags were introduced into the godown.
The following chemical tests for estimating the extent of the diffusion of the gas were arranged :—

The paste (described in Scientific Memoirs, No. 38) was applied to the inside of glass tubes, which were placed in the following situations—

(*a*) at 6 different levels from floor to roof of godown ;
(*b*) one tube along with each bag of fleas in the rice bags ; and
(*c*) tubes open at one end and ringed inside with paste (1) at the top or open end, (2) in the middle, and (3) at the bottom or closed end. A set of these was placed horizontally and a set vertically.

The amount of solution of potassium cyanide used was equal to ½ oz. KCN per 100 cub. ft. godown space.
Generation occupied 5 minutes.
Circulation was continued for 1 hour.
Blowing out was carried on for another 10 minutes and the godown was then entered.

Results :—

Rats—All dead.
Fleas—In test tubes—all dead.
In muslin bags outside grain bags—all dead.
In muslin bags introduced 35 minutes from start—all dead.
Beneath bag but on surface of rice—all dead.
1″ below surface of rice—all dead.
2″ below surface of rice—1 living, 9 dead.
3″ and 6″ below surface of rice—all living.

A control grain bag with fleas placed at different levels had been prepared in a similar manner to that used in the fumigated godown and gave the following results :—

Fleas under bag but on surface of the rice, all alive.
„ 1″ below surface—1 dead and 9 alive.
„ 2″ „ „ 1 „ „ 9 „
„ 3″ „ „ all alive.
„ 6″ „ „ „ „

Chemical tests.—The tubes placed at different levels all gave a strong Prussian blue test. The tube placed along with the fleas under the bag but on surface of the grain gave a weak test. Those placed at 1″ below the grain and deeper gave no appreciable test, the gas had therefore penetrated the rice to so small an extent as to be detected with difficulty by this chemical test. It appears that the gas will kill fleas when present in such small quantities as not to be detected by this test.

The sets of tubes closed at the end gave similar results whether placed horizontally or vertically. A strong test was obtained at the open end, a weak test in the middle, and a very faint one at the closed end.

Third Series.

Gas generated by mixing solutions of equal parts of strong concentrated sulphuric acid and water with a 50% solution of potassium cyanide in water. Experiments carried out in a barge with two holds each of 6,000 cubic feet capacity. The barge was not laden.

Experiment No. 14.—One hold used, capacity 6,000 cubic feet.

KCN (50%) solution used, 1,800 c.c. = ½ oz. per 100 cubic feet.

69 rats were placed in cages in different parts of the hold above the floor planking.

29 rats were placed in cages below the planking and the planking replaced.

270 fleas in test tubes each containing 10 fleas were distributed about the hold, and under the planking.

Generation of the gas commenced at 2-55 P.M. and completed by 3-40 P.M. (¾ hours).

Circulation by means of the fan was continued for 15 minutes more (till 3-55).

The hatch was opened at 4 P.M. and the hold entered 5 minutes later.

Results:—

All 69 rats above the boarding were dead.

All 270 fleas were dead, both above and below the floor.

Of the 28 rats below the boarding, 19 were dead and 9 alive, but very sick. Of these two more died later.

Percentage mortality:—

	Per cent.
Fleas (all situations)	100
Rats above boarding	100
Rats below boarding	75

Experiment No. 15.—Both holds used, total capacity 12,000 cubic feet.

KCN (50%) solution, 3,600 c.c. = ½ oz. per 100 cubic feet.

Of the 9 one-inch distributing pipes, four were placed in one hold and five in the other. A 3″ return pipe was placed in each hold.

25 rats in cages were placed above the boards and 25 below the boards, in each hold.

50 fleas were also introduced in tubes into each hold above and below the boards.

Generation was commenced at 2-10 P.M., and was completed in 40 minutes, and circulation was continued for 50 minutes more.

The tarpaulins were then removed (1½ hours from start) and the holds entered, 5 minutes later.

Results:—

All fleas dead.

All rats above boarding in both holds, dead.

Of the 25 rats below the planks in each hold, 9 were dead in each = 18 altogether.

Of the 32 living rats, 9 more died later.

Percentage mortality:—

	Per cent.
Fleas	100
Rats above boarding	100
Rats below boarding	..
Immediate	36
At the end of 12 hours	54

Tubes containing the test paste which had been placed about the hold gave a strong Prussian blue test above the planking but those placed below the boards along with the rats showed that the concentration of the gas in this situation had been very low.

Experiment No. 16.—The same two holds were used, four delivery pipes being introduced into the Forward-hold and five into the After-hold.

The amount of KCN solution used was intended to be ½ oz. KCN per 100 cubic feet but only $\frac{5}{12}$ oz. was used on account of certain troubles in mixing the solutions.

The exposure was much longer than in experiment No. 2, being 4 hours instead of 1½ hours.

50 fleas were placed below the boards in each hold. Rats introduced as follows :—

Forward-hold :—

In cages above boards	20
In cages below boards	25
Rats loose in hold	48
Total	93

After-hold :—

In cages below boards	20
In cages above boards	25
Rats loose in hold	41
Total	86

Generation was commenced at 11-45 A.M., and completed by 12-30 P.M. (¾ hour).

The concentration of the gas in the hold was tested at 3-45 just before opening the hatches and was found to be very weak. The holds were then opened and entered (4 hours from commencement of experiment).

Results :—

All fleas in both holds—dead.

All rats in cages above boarding—dead in both holds.

Rats in cages below floor—

After-hold :— All dead.

Forward-hold :— 5 out of 25 living.

Rats loose in holds—

After-hold :— 46 out of 48 dead.
None found alive, two escaped out of hold before or during disinfection.

*Forward-hold :—*37 out of 41 dead, 3 living, one escaped from the hold before or during disinfection.

The loose rats were found dead in all situations both above and below planking floor.

Experiment No. 17.—The same holds were used and KCN to the full amount of ½ oz. per 100 cubic feet was employed.

The 4 pipes were on this occasion placed in the After-hold and 5 in the Forward-hold.

Rats introduced :—

After-hold :—

Rats in cages above floor	22
Rats in cages below floor	25
Rats loose in hold	50

Forward-hold :—

Rats in cages above floor	20
Rats in cages below floor	30
Rats loose in hold	50

Seven rats escaped, 3 from After-hold and four from Forward-hold during or before disinfection.

Generation was commenced at 11-17 and completed by 11-47, half an hour.

At this termination of generation a strong concentration of the gas was found in the holds by chemical test. The holds were opened and entered four hours from the commencement of the experiment.

Results :—

	After-hold.	*Forward-hold.*
Rats in cages above floor ..	All died.	All died.
Rats in cages below floor ..	,,	,,
Rats loose in hold	41 died & 6 alive.	44 died & 2 alive.

Percentage of mortality :—

	Per cent.	Per cent.
Rats in cages above floor ..	100	100
Rats in cages below floor ..	100	100
Rats loose in hold	87	96

NOTE ON SOME POINTS OF INTEREST REGARDING VITAL STATISTICS.

BY

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IN view of the importance now-a-days attached to the study of vital statistics in civilized countries it is somewhat disappointing to find that the subject appears to possess little interest for the Indian sanitarian. It is possible that the unsatisfactory materials at his disposal are mainly responsible for this, for as is well known, the only certain fact about Indian vital statistics is their inaccuracy. But this should stimulate rather than discourage the scientific worker, for it points to the need for systematic investigation by careful observers in an almost untouched field of research. And although it may be some time before we may hope to see any remarkable improvement in the recording of vital statistics as the result of such investigation, there is every possibility that it may throw some light on such questions as maximum and minimum birth-rates of Indian communities, the relative fecundity of Indian races, infantile mortality and many other interesting problems.

Inaccuracy of Vital Statistics.—Although it is generally admitted that the returns of vital occurrences are not accurate it is frequently assumed that the error is comparatively insignificant. In the recent Bengal Census it is stated that—

"On the whole the number of omissions is comparatively small" and in another paragraph—

"In towns the higher level of intelligence and the fear of legal penalties tend to make registration and the classification of diseases more accurate than in the rural tracts."

In support of the view that the recording of vital occurrences is not far from complete, the percentage of omissions discovered by the Vaccination inspection staff from 1901 to 1910 is given in the Census Report as follows :—

Year.	Percentage of omissions discovered.	
	Births.	Deaths.
	%	%
1901	1·23	0·99
1902	0·85	0·66
1903	0·80	0·62
1904	0·91	0·81
1905	0·87	0·72
1906	0·66	0·61
1907	0·68	0·57
1908	0·42	0·38
1909	0·28	0·30
1910	0·42	0·29

But it is only necessary to glance at any of the annual sanitary reports of the Province to realize how misleading such a view must be.

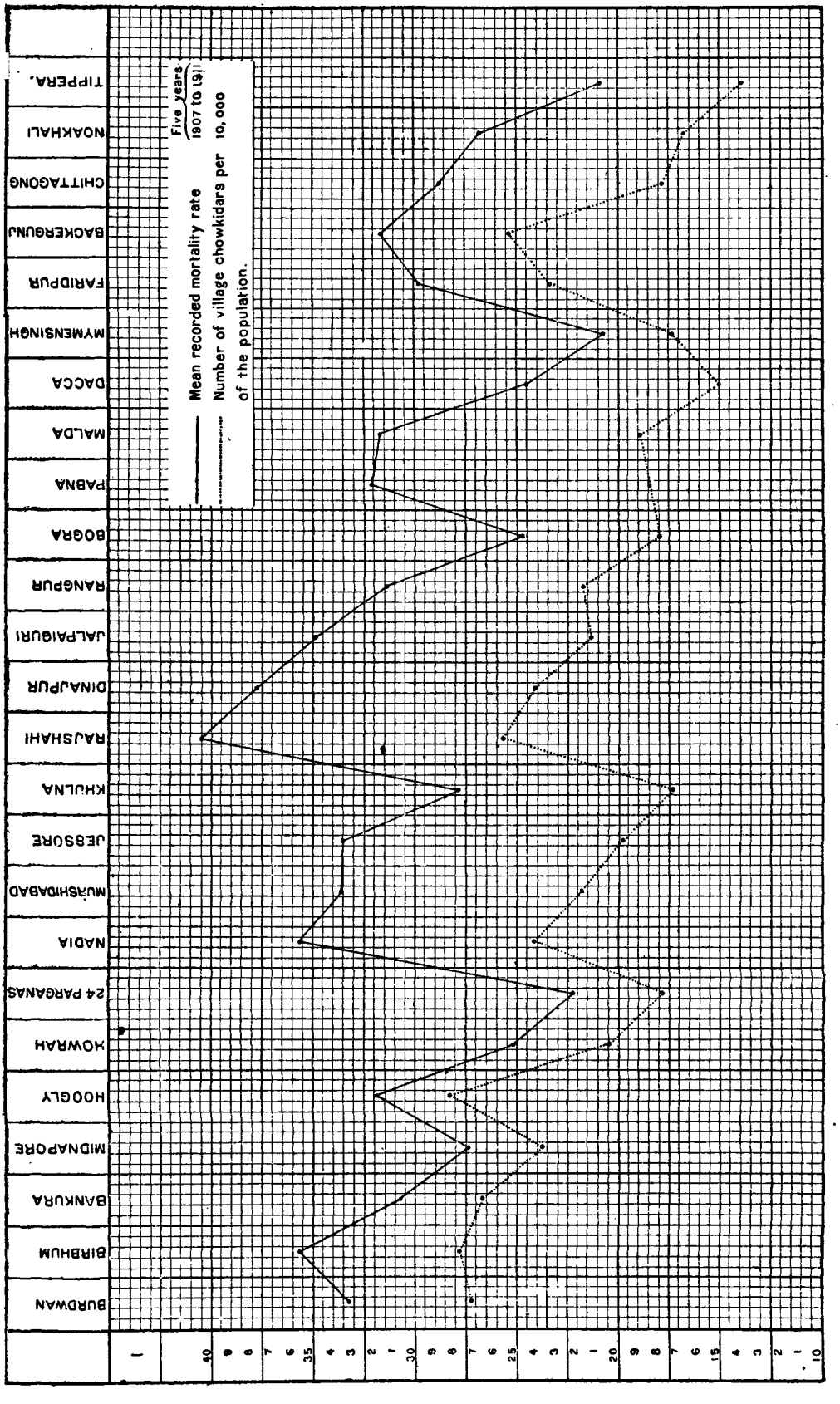
Towns.—Among the 112 towns in Bengal, 44 or nearly 40 per cent. returned a mortality rate of under 20 per 1,000 of the population during 1912 ; in the case of 27 or 24 per cent. the rate was under 15 per 1,000 ; and in the following eleven towns it was under 10 per 1,000.

	Towns.	Population.	Recorded deaths.	Ratio per 1,000.
West Bengal ..	1. Asansol ..	21,919	122	5·56
	2. Budge-Budge	17,982	172	9·56
	3. Baruipur ..	6,375	60	9·41
	4. South Barrackpur	27,605	220	7·96
	5. Tittaghur..	45,171	176	3·89
	6. Bhatpara	50,414	444	8·80
	7. Kushtia ..	6,095	57	9·35
East Bengal ..	8. Mymensingh	19,853	146	7·35
	9. Barisal ..	22,473	209	9·30
	10. Jhalakati	5,979	30	5·01
	11. Comilla ..	22,692	181	7·97

Extraordinarily low birth-rates were also reported from a number of towns as follows :—

	Per 1,000.
Tittaghur	2·52
Jhalakati	3·34
South Barrackpur	5·03
Baruipur	6·43
Jessore	6·50
Asansol	8·21
Kushtia	8·85
Mymensingh	9·31

Curves showing probable relationship between recorded mortality rates in Bengal districts and number of village chowkidars.



Such figures as these can only be explained on the grounds of wholesale omissions in the registration of vital occurrences ; and this view is supported by the fact that wherever independent investigation has been undertaken a large percentage of omissions has been discovered. Thus in 1911 investigation at Chittagong town brought to light the fact that 41 per cent. of vital occurrences went unrecorded. A similar house-to-house enquiry in a portion of Dinajpur town in 1912 revealed 35·5 per cent. of deaths and 31·1 per cent. of births unreported ; and in a paper read before the Sanitary Conference at Madras last year Dr. Brahmachari, Health Officer of Cossipore-Chitpore, showed that, during the period 1903 to 1908, the percentage of omissions in the Police register of deaths in that municipality varied between 66·2 per cent. to 78 per cent.

Rural areas.—The recording of vital occurrences in rural areas in Bengal is also very incomplete. Recent house-to-house enquiry in certain villages in the Faridpur district brought to light 453 deaths of which 132 or 29·13 per cent. had not been recorded at the thana. Similarly, of 194 births 102 or 52·5 per cent. had not been registered Further, investigation in regard to the recording of births in three other districts appears to show that at least one-fourth or one-fifth of the births are generally unrecorded.

The recording of vital occurrences in the rural areas of Bengal is one of the duties of the village chowkidars. The pay of these men is low, a very small proportion of them are literate and they generally perform their duties in a careless and inefficient manner. There are over 87,000 of them in the province. If they were evenly distributed each man should have on the average to record a total of from 40 to 60 births and deaths during the year. Roughly speaking, we may say that if each man omits to record on the average 1 birth or 1 death, the recorded birth-rate or death-rate of the province will be 2 per 1,000 of the population below the actual. There are good reasons for supposing however that the error in registration is by no means uniform all over the province, and this appears to be largely due to the unequal distribution of the chowkidars in different districts. Examination of the accompanying curves will show that districts which possess a high proportion of chowkidars per 10,000 of the population invariably show a relatively high mortality, and districts with a low proportion of chowkidars record a low mortality. This fact shows that we cannot reasonably compare the vital statistics of one district with another, or assume without further investigation that, because one area returns a higher death-rate than another, it is necessarily the more unhealthy.

Fecundity of Indian races.—The necessity for careful investigation of such questions as the relative fecundity of Indian races is shown by the extraordinary variation in the returns from different districts of a single province. Reference to the accompanying statement will show that in Bengal during 1912, Murshidabad district returned a number of births equivalent to a ratio of 267 per 1,000 married women aged 15-40, whereas Tippera district returned births equal to a ratio of 182 only. The recorded birth-rate of the different districts of the province varied between 29·58 per 1,000 for the 24-Parganas (excluding Calcutta) to 44·41 per 1,000 for Noakhali. But in a number of *thanas* birth-rates were registered considerably exceeding 50 per 1,000. Unfortunately we do not know what the normal birth-rate of Indian communities is, although there are grounds for supposing it to be as high as 55 to 65 per 1,000 of the population, and until the point has been carefully investigated it is idle to speculate upon the causes of these extraordinary variations, although we may be quite certain that inaccuracy in the records is responsible for a very considerable error.

Infant Mortality.—The question of infant mortality receives very great attention in Western countries, but in India it attracts but little notice. In Bengal the proportion of infant deaths to the total recorded, varies from 19·6 per cent. in the Jessore district to as high as 31·5 and 31·7 per cent. in the two adjoining districts of Khulna and Bakerganj. The ratio of infant deaths to births varies from as low as 164 per 1,000 in Pabna to as high as 286 in Jalpaiguri district. A recent investigation into the age at which infants die has given the following results :—

District.	Thana.	Infant deaths occurring during the first month of life.
		%
Dacca	Keraniganj	61·0
Rajshahi	Natore	64·4
Burdwan	Galsi	69·0

and of the total infants dying, from 27 to 33 per cent. died within 24 hours after delivery. The annexed statements B, C and D give further particulars of the age at which infant mortality occurs in Bengal.

Fever Mortality.—Before concluding this paper attention must once more be drawn to the unsatisfactory method which is still persisted in throughout India of recording deaths under the head "Fever." In Bengal a number of enquiries have been undertaken from time to time into the causation of deaths so recorded. In

1904 Rogers investigated 1,104 " fever " deaths in Dinajpur district and reported that only 318 or 28·80 per cent. were due to malaria and kala-azar. In 1906, Stewart and Proctor working in Central Bengal reported that out of 835 " fever " deaths, only 302 or 36·1 per cent. could really be ascribed to malaria, acute and chronic. In 1906 and 1909 out of 4,859 " fever " deaths in the Burdwan district, investigation showed that at the most only 2,500 or 51·45 per cent. could really be put down to malaria. In 1911 among 211 fever deaths examined into at Dum-Dum, 34·7 per cent. only were in any way connected with malaria. Similar investigation in the Dacca district has shown that although 4,304 " fever" deaths were reported by the village chowkidars in the Keraniganj *thana*, only 1,212 or 28·15 per cent. were due to malaria. At Dinajpur town also of 317 fever deaths investigated, only 105 or 33·3 per cent. were due to malaria ; and at Cossipur-Chitpur, Dr. Brahmachari discovered that only 12·4 per cent. of the recorded " fever " deaths were due to this cause.

In view of these facts the existing procedure, whereby all deaths recorded as due to " fever " are pooled in the Sanitary reports all over India, and discussed with but little qualification, is bound to give rise to misconception and to afford some sort of support to misleading statements such as the one quoted below, which recently appeared in the newspapers.

"MALARIOUS MIDNAPORE."

(Associated Press of India.)

Midnapur, October 26th, 1913.

"The latest vital statistics, published under the authority of the Government of Bengal, show that in the month of July last out of the total number of about 4,500 deaths, 4,000 cases were from fever within the village areas of the Midnapore district, exclusive of the municipal jurisdiction.

Midnapore has been, as already reported, declared a malarial area and free distribution of quinine recommended and sanctioned throughout the malaria-stricken areas of the district."

The frequency with which mis-statements of this kind regarding recorded " fever " mortality in India are to be met with, suggests the urgent necessity for modifying the existing system of recording and discussing the causes of death in the Sanitary reports, not only of Bengal but of the other provinces as well.

STATEMENT A.

	Name of District.	Birth per 1,000 married women aged 15 to 40 during 1912.	Infant mortality per 1,000 births in 1912.	Percentage of infant deaths to total deaths during 1912.	Mean rates of births per 1,000 during previous five years (1907-11).
	Burdwan Division.				
Western Bengal.	Burdwan	183	251	23·9	31·53
	Birbhum	202	249	24·8	33·98
	Bankura	220	209	25·2	36·18
	Midnapur	192	235	22·2	33·56
	Hooghly	201	227	20·4	32·12
	Howrah	212	204	23·9	30·62
	Presidency Division.				
Central Bengal.	24-Parganas ..	187	194	20·5	23·80
	Calcutta	198	259	20·0	19·93
	Nadia	244	221	23·1	41·39
	Murshidabad ..	267	223	26·1	31·81
	Jessore	204	203	19·6	33·35
	Khulna	241	240	31·5	35·87
	Rajshahi Division.				
Northern Bengal.	Rajshahi	242	203	23·1	39·90
	Dinajpur	246	261	28·1	39·41
	Jalpaiguri	204	286	28·1	35·86
	Darjeeling	233	220	20·6	32·37
	Rangpur	225	222	27·5	36·31
	Bogra	218	170	28·5	35·28
	Pabna	220	164	23·0	32·81
	Malda	225	248	20·8	41·22
	Dacca Division				
Eastern Bengal.	Dacca	204	206	26·6	35·83
	Mymensingh ..	186	183	28·1	32·16
	Faridpur	230	217	27·3	36·18
	Bakarganj	236	233	31·7	35·61
	Chittagong Division.				
	Chittagong	230	175	25·4	37·48
	Noakhali	259	156	26·3	39·87
	Tippera	182	175	25·4	32·67

STATEMENT B.

Ages by monthly periods of infants recorded as dying in Rajshahi, Burdwan and Dacca districts.

Age in months up to	Rajshahi Natore Thana.		Burdwan Galsi Thana.		Dacca Keraniganj Thana.	
	No.	Percentage.	No.	Percentage	No.	Percentage.
1	326	64·4	554	68·47	695	60·3
2	38	7·4	39	4·8	107	9·2
3	33	6·4	41	5·0	99	8·6
4	21	4·1	21	2·5	37	3·2
5	17	3·3	14	1·7	42	3·6
6	16	3·1	21	2·6	52	4·5
7	14	2·7	10	1·1	27	2·3
8	13	2·5	14	1·7	30	2·6
9	13	2·5	12	1·1	34	2·9
10	7	1·3	14	1·7	15	1·3
11	3	0·5	3	0·3	6	0·5
12	8	1·5	66	8·3	8	0·7
Total ..	509	..	809	..	1,152	..

STATEMENT C.

Particulars of age at death of 695 *infants dying* (1 *month and under*) *in the Dacca district. Taken from chowkidars' records.*

	Dying within 24 hours of birth.	Dying over 1 day and under 8 days.	Dying over 7 days and under 15 days.	Dying over 14 days and under 22 days.	Dying over 21 days and under 29 days.	Recorded as 1 month old at death.	TOTAL.
DACCA Keraniganj Thana.	166	232	114	72	27	84	695
	23·8%	33·3%	16·4%	10·3%	3·9%	12·0%	..

Particulars of age at death of infants dying, aged 1 *month and under, verified and corrected by reference to birth register.*

	Dying within 24 hours of birth.	Dying over 1 day and under 8 days.	Dying over 7 and under 15 days.	Dying over 14 days and under 30 days.	TOTAL.
BURDWAN Galsi Thana.	66	26	18	28	138
	47·8%	18·8%	13·0%	20·2%	
DACCA Keraniganj Thana.	37	30	20	10	97
	38·1%	30·9%	20·6%	10·3%	

STATEMENT D.

Ages of infants at death in monthly period corrected by reference to birth records.

Note.—Galsi Thana is malarious, but this portion of Keraniganj Thana dealt with is practically non-malarious.

	Months. 1	2	3	4	5	6	7	8	9	10	11	12	TOTAL.
BURDWAN Galsi Thana.	138	9	11	7	4	4	2	5	6	2	1	10	199
	69·3%	4·5	5·5	3·5	2·0	2·0	1·0	2·5	3·0	1·0	0·5	5·0	..
DACCA Keraniganj Thana.	97	15	3	2	3	4	6	3	1	3	0	0	137
	70·8%	10·9	2·1	1·4	2·1	2·9	4·3	2·1	0·7	2·0	0·0	0·0	..

NOTE ON SOME SIMPLE METHODS OF TESTING THE REGISTRATION OF VITAL OCCURRENCES IN INDIA.

BY

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Special Deputy Sanitary Commissioner, Bengal.

IN connection with the investigation of malaria in Bengal it has become necessary from time to time to enquire into the recording of vital occurrences in different parts of the province, and in the course of this enquiry certain simple methods of testing the accuracy with which vital occurrences are recorded have suggested themselves to the writer, as (1) providing officers of the Sanitary Department with a ready means of gauging to some extent the accuracy of the returns of the vital occurrences; and (2) being eminently suitable for application in nearly every part of India. Of the three tests described in the following paper, the first two can be carried out by the ordinary clerical staff of the Sanitary Department, the bulk of the work being simple office work. Both of these tests have already been made use of to a limited extent by the writer. The third method which has not yet been tried is a suggestion for certain enquiries to be carried out by the Vaccination Inspection staff which is already utilized for the supposed testing of registration.

Test No. 1 offers a means of ascertaining with considerable accuracy the proportion of omissions in the record of births. Tests Nos. II and III will show the recorded and the actual infant mortality respectively for a given number of actual births and when used together will give a fair idea of the proportion of omissions in the record of deaths.

For the application of tests I and II it is necessary to secure the *hathchittas* of a number of village chowkidars. Old books may be used, provided that both the birth books and the complementary death books for a given period, extending if possible over at least 13 months, are available. Suppose we possess the complete records of a *thana* from December 1st, 1911, to December 31st, 1912. From the complementary records for these 13 months we must prepare certain lists, two for each chowkidar,

(A) a list of all the infant deaths recorded during the period;
(B) a list of all the births recorded during the 13 months.

In order to test the error in birth registration we require both list A and list B. From list A we take all the infant deaths recorded in the last month and go carefully through the birth records of the preceding 12 months, noting down against each infant death the date at which the birth of the child was recorded. In many cases it will be found that though deaths of infants have been recorded, their births have not been registered.. The percentage of such omission gives the crude error in the recording of births.

By this method it was found that out of a total of 938 infant deaths recorded in the Galsi *thana* of the Burdwan District, the births of 246 or 26·22% had not been registered. Similarly in the case of 1,660 infant deaths recorded in the Keraniganj *thana* of the Dacca District, 519 births or 31·26% had not been recorded. And at the Natore *thana* of the Rajshahi District in the case of 447 infant deaths, 106 births or 24·16% had not been entered in the register.

When these facts were first brought to light it was at once suggested by the Vaccination Inspectors of the respective areas that the apparent error in registration of births was due entirely to the fact that in Bengal, as is well known, many women go to their father's house for child-birth, especially in the case of the first child; and that it frequently happened that the birth of a child was recorded at one place and its death at another. But this statement after being carefully tested was found to fall very short of the truth. Enquiry regarding 1,110 births recorded in the areas investigated brought to light the fact that in 88% the births took place in the husbands' *bari*, in less than 12 per cent. only was a child born away from its father's house.

As investigation has shown that of the recorded infant deaths more than two-thirds take place during the first month of life, and as children are rarely or never removed from the house in which they are born until they are at least a month old, it will be seen that the birth of children away from their own homes could account at the most for only a small proportion of the omissions discovered; probably not more than 5% of the total instances recorded being influenced in this way. Deducting 5 from the percentage of omissions discovered in each district, gives us the following figures :—

District.	Thana.	Crude error.	Correction factor.	Percentage of actual omissions.
Burdwan	Galsi	26·22	—5 —	21·22%
Dacca	Keraniganj ...	31·26	—5 —	26·26%
Rajshahi	Natore	24·16	—5 —	19·16%

If these figures can be taken as fair samples for the *thanas* they represent the true birth-rates should stand at :—

Galsi	45·74%
Keraniganj	49·43%
Natore	19·16%

instead of Galsi 36·04 per cent., Keraniganj 36·45 per cent., Natore 51·48 per cent., the recorded figures.

The application of test II is very similar to that of test I, the only difference being that the births in the first month of list B are carefully compared with the death records of the following 12 months, and the deaths of any of the infants whose births are recorded in the list are carefully noted. By applying this test in the case of 1,491 births registered at the Galsi *thana* of the Burdwan district it, was found that 309 of the children were recorded as having died during the 12 months succeeding their birth, giving a recorded infant mortality of 209 per 1,000 births. Similarly, investigation of the records in the Keraniganj *thana* of the Dacca district showed that of 1,070 children whose births were recorded only 112 were subsequently recorded as having died during the year following their birth, giving a ratio of only 104 deaths per 1,000 births. In the Natore *thana* of the Rajshahi district only 147 births were followed up and of these children only 9 were recorded as dying in the 12 months following birth, giving a ridiculously low ratio of 61 deaths per 1,000 births. In this case of course the number dealt with is too small to afford reliable results.

It may be mentioned that the infantile mortality recorded in these three *thanas* during 1912 was as follows :—

	Ratio of infant deaths to 1,000 births.
Galsi	240·31
Keraniganj	228·72
Natore	247·04

Test No. II has not by itself the same value as test No. I, but if combined with the special enquiry suggested as test III it would afford important information both as regards (A) the actual infantile mortality, and (B) the probable error in the recording of deaths.

The proposal for test III is as follows :—

Instead of giving more or less vague instructions to the Inspectors and Sub-Inspectors of Vaccination to verify vital occurrences, special lists should be prepared of children whose births had been recorded during a given period, about a year previously. The Sub-Inspectors of Vaccination should be ordered to visit the respective villages and houses in which these children were born to make careful enquiries, if possible, examining the children, and to submit a complete report showing, (*a*) how many children were alive and had been vaccinated, (*b*) how many children had died, with the date of their death, and (*c*) how many children were to be found in their birth-place and how many had been removed to other places.

If each Sub-Inspector of Vaccination were given a list of 1,000 births that had been recorded a year previously, it would be possible to deduce from his report a fairly correct idea of the true infantile mortality in his Sub-Division. And by comparing his list of deaths with those prepared for test II in the office it would be fairly easy to calculate the proportion of deaths of infants that had escaped registration.

In carrying out this work it would be wise to lay most emphasis on the examining of children for vaccination, as if too much stress were laid upon the verification of deaths, the temptation to fill in the returns from the chowkidars' books would be very great. It is this tendency which, in Bengal at least, makes the so-called verification of vital statistics by the Vaccination Staff an absolute farce at the present time.

REGISTRATION OF VITAL STATISTICS.

BY

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IN the All-India Sanitary Conference of 1911 Major Robertson put forward a scheme for the registration of vital statistics in municipalities, in extension of the scope of which the following suggestions are made—

In the parts of India in regard to whose civil administration I have personal knowledge, *viz.*, Assam and the districts of East Bengal, I have frequently observed that registration is appreciably better in rural areas, than in towns, despite the more advanced stage of administration and enlightenment in urban areas. The ultimate reason for this difference lies, I consider, in the fact that the system in vogue in urban areas is unsuitable.

Under the Eastern Bengal system of registration, the collecting agent in both rural and urban areas is the police. In urban areas, in accordance with Act IV, B.C., of 1873, the public are responsible for reporting vital occurrences verbally at the thana, or in writing, through the beat constable.

In Assam municipalities, Act IV, B.C., is administered by the Municipal Commissioners.

Special Registration Officers, called Ward Gaonburas, are appointed, to whom the public should report vital occurrences.

I have frequently had occasion to note that the larger the town, and the higher the standard of education of its inhabitants, the worse the registration. Deputy Magistrates, Pleaders, small land owners and the better class people in general, are the worst offenders. There is no public opinion in favour of registration, and the whole process is looked upon as a vexatious inquisition on the part of Government.

Such an attitude on the part of the leaders naturally has its reflection in the lower grades of society and the net result is that in extreme cases 30% to 50% of vital occurrences in urban areas may escape record.

If we put ourselves in the place of these recalcitrant gentlemen their objections are not unreasonable. A good caste man feels a certain amount of loss of self-respect involved in fulfilling the obligations to register by putting a constable, or low class Ward Gaonbura in possession of intimate details regarding family events. The obligation being distasteful, and one from the fulfilment of which he receives no advantage, it is frequently forgotten, and thus left undischarged. Subsequently the enquiries of a member of the investigating agency, *i.e.*, the vaccination inspecting staff, may bring the default to light; the defaulter is brought before a Magistrate who is most probably in full sympathy with him; he incurs a nominal penalty which is no real deterrent to others, while the operation of the law brings the cause of registration further into disfavour.

We must carry public opinion with us in all our public health measures, else they are doomed to failure, and that we have not got public opinion with us in the matter of registration, is, I am convinced, the main cause of our failure in urban registration.

Major Robertson's proposals that Medical Registrars of the grade of Sub-Assistant Surgeons be appointed, has an application beyond that of the increased accuracy of diagnosis of the causes of death. I think it would be found that the reluctance at present felt by many to inform a constable or gaonbura of family events, would not be felt to the same extent in reporting to an educated medical man of some social standing.

A further inducement might, however, be offered. Now-a-days with the increase in the business done by Insurance companies and the difficulties which must occasionally arise in certification of the cause and date of death, the necessity of proving the age of applicants for Government service, and in litigation, a proof which in Bengal has to be extracted from the evidence of a horoscope, and for many other reasons arising from the advances in the complexity of social life, it appears to me that the time has come for instituting some Government system of certification of births and deaths.

My proposals shortly are these, that the Medical Registrar of the Municipality should supply the "qualified informant" with an authenticated copy of the entry made in the register, and that such birth or death certificates should be given a definite legal status and accepted as evidence of birth or of death.

This can be done in extension of Act IV, B.C., of 1873, and without conflict with any other statute, such as the Imperial Registration Act, VI of 1886, which provides for optional registration of births and deaths among Christians and Eurasians. Its place could be supplied by an extension of the compulsory Act on the lines I have suggested.

In conclusion, my contention is this, that if the well-to-do and educated classes found that their obligation to register vital occurrences meant only a few minutes interview with, or a letter to, a medical man of their own standing, and that in return for this, they were to receive a duly authenticated certificate of birth or death, which would be of value to their children in their future career, or of immediate service in claiming an Insurance premium, or as evidence in family litigation regarding an estate, etc., then their attitude towards registration would become more friendly. With the help of the public thus enlisted, we might hope for a degree of improvement in the accuracy of urban registration, which is unattainable under the present primitive conditions.

A scheme for the improvement of registration upon the lines indicated above is now under the consideration of the Assam Administration.

NOTE ON THE REGISTRATION OF VITAL STATISTICS IN SIND.

BY

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1. Registration of births and deaths is compulsory in Karachi city only. Information is, in the first instance, collected at six stations (open during most part of the day) by sub-registrars who are vernacular clerks and are under the control of the Registrar of Births and Deaths. The latter officer is also Superintendent of Vaccination for the city and is subordinate to the Deputy Sanitary Commissioner in both duties. The information collected by the Superintendent and his staff is finally reviewed and published by the Health Officer of Karachi. The information obtained by this simple and inexpensive staff is in all respects, except as regards cause of death, as reliable as could be obtained. Thus the birth-rate for 1912 was 48·88 per mille of population and the death-rate 44·49, and when the fact that a large section of the population consists of males whose wives and families live elsewhere in Sind, the birth-figure indicates that default is inappreciable.

2. The other municipalities in Sind, generally speaking, do not fully realise the importance of vital statistics, registration is voluntary, and the collection of information is done by the Municipal Secretary and his staff on no regular system, and consequently the figures indicate a large default. Thus for the year 1912 the birth and death-rates per mille of population were respectively 34·48 and 36·21.

3. In rural areas, including nearly all non-municipal towns, the registrar is the *toppedar* who is the ultimate revenue subordinate, the area in his charge being called a *toppa*. He gets his information during his rounds of revenue duty by enquiries (1) personally, or (2) through the medium of his *kotar* or *chaprassi*, also through the agency of (3) schoolmasters, pound moonshis or of zamindars, shopkeepers and other private individuals ; each of the latter keeping a sub-record for his village or area and the *toppedar* is supposed to copy the entries into his own (official) register (Form No. 14). Only a small part of the rural areas is covered by these sub-records and the recording of vital statistics therefore rests mainly on the *toppedar's* unaided efforts. His record on Revenue Form No. 14 is copied by him into Sanitary Form No. 11, which he submits to the mukhtiarkor (the Revenue Officer in charge of the Taluka), for transmission to the Deputy Sanitary Commissioner's office, where the statistics are compiled.

The great majority of deaths are returned as due to fever.

The total figure so obtained when compared with those for Karachi city or even with the faulty figures of the smaller municipalities, indicate a very high percentage of default in the registration of births and deaths in the rural areas in Sind.

It should be noted that one of the reasons for default as regards births is that many people deliberately evade registering in the hope of evading the attentions of the vaccinator. A good many of the schoolmasters and pound moonshis n Nawabshah District are paid Re. 1 per month for the duty of recording births and deaths, but generally the sub-registrars in Sind are unpaid. Many of them keep their records fairly well. The *toppedar*, on the other hand, has proved on the whole a failure as a registrar. When he is not assisted by sub-registrars his recorded birth and death-rates are low. When there are sub-registrars he contents himself with copying their books irregularly (often omitting many of the entries) and recording few or no births and deaths for the remainder (generally the greater part) of his *toppa*. The *toppedar* therefore is responsible for the bulk of the default in registration. The following table shows the result of an inspection made this month of the birth registers for the current year of a taluka of 24 *toppas* :—

Registration in Singharo taluka, Nawabshah District.

	No.	Combined population.	Birth-rate per 1,000 of population.	No. of birth entries not copied by the *Toppedar*.
1. Toppas in which there is no sub-registrar.	15	25,738	15·42	
2. Toppas in which there are sub-registrars.	9	17,962	18·26	15 (approximate).
(*a*) recorded by sub-registrars.		7,658	24·81	
(*b*) ,, ,, Toppedar alone.		10,304	13·49	
TOTAL FOR TALUKA ..	24	43,700	16·59	

IMPROVEMENT IN REGISTRATION OF BIRTHS AND DEATHS.

1.—In Karachi City.

In Karachi city what is needed is reliable information as regards cause of death.

It seems useless to attempt improvement in that direction until Western methods of treatment are more largely adopted by the people; under present conditions compulsory notification of death by the regular medical practitioners—even if it could be adopted—would effect but little.

2.—In the rest of Sind.

In the smaller municipalities and in the rural areas, for the same reason as stated for Karachi city, accurate information as to cause of death is not likely to be obtained. More thorough recording of the simple fact of birth or death is first to be desired and as the figures given show there is here a large field for improvement. Compulsory registration is as likely to be effective as it is in Karachi city if carried out on the same lines.

In the rural areas registration is, as shown above, in a very backward state. The *toppedar* seems to regard registration of births and deaths as an outside and unimportant part of his work and probably his various other duties do not leave him time to give the matter much attention. However, even without altering the present system, much could be done to get a more complete record of births and deaths and suggestions with that object in view, on the following lines, have been put forward by the Deputy Sanitary Commissioner to the Collectors of the Districts in which a full inspection of birth and death registers has been made.

1. That sub-records be distributed more extensively so that there should be one for every village where a resident can be found who would take charge of it.

2. That the returns for as many of the larger villages as is feasible be submitted direct to the Deputy Sanitary Commissioner. This would relieve the *toppedar* of much of his copying work and at the same time there would be a direct check on the efficiency of the sub-registrar.

3. That small payments be made to those volunteer sub-registrars to whom payment would be acceptable, and rewards such as *afrinamas*, thanks in the Collector's Durbar, etc., be given to the others contingent on their keeping their records well.

4. *Toppedars* to be made to realize the importance of keeping a thorough record of births and deaths. Failure on the part of *toppedars* to copy sub-records and carelessness in registration be regarded as a serious failure in duty.

I would make the following suggestion with regard to pound moonshis. They are pensionable vernacular clerks whose duty is merely to take charge of the cattle-pounds, but in addition they are generally employed by the village sanitary committees as sanitary moonshi on a small monthly allowance. Generally speaking, the pound moonshi is the best registrar of births and deaths, and I am of opinion that he could be a very useful official in the cause of registration as well as of Public Health generally if he were primarily a sanitary moonshi, included, trained, promoted, etc., as such, with the pound as his additional, instead of his chief, charge.

NOTE ON A REINFORCED CONCRETE PIPE FOR AHMEDNAGAR WATER-SUPPLY.

BY

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IN connection with the proposed reinforced concrete rising main for the Ahmednagar water-supply a set of twenty reinforced concrete pipes have been made and hydraulically tested. The statement of the tests is attached. Four different amounts of reinforcing metal have been used, suitable for various heads, *viz.*:—

Type No.	Suitable for heads.	No. of longitudinal rods.	Section of longitudinal rods.	Circumferential reinforcement diameter of spirally wound wire.	Pitch of spiral.
1	40′	8	$\frac{3}{8}'' \times \frac{3}{8}''$	$\frac{1}{4}''$	$3\frac{1}{2}''$
2	Above 30′	8	Do.	$\frac{1}{4}''$	4″
3	„ 20′	8	$1'' \times \frac{1}{8}''$	3-16″	3″
4	Below 20′	8	Do.	3-16″	5″

2. The details of pipe dimensions were as follow :—

Length	8′
Internal Diameter	16″
External	21″
Thickness	$2\frac{1}{2}''$

3. The mixture of concrete was in the following proportions:—

Portland Cement (Ferrocrete Brand)	200 lbs.
Medusa Waterproofing Cement	$1\frac{1}{2}$ „
Shingle, river, screened and washed $\frac{1}{4}''$ to $\frac{1}{2}''$	4 cu. ft.
Sand, river, washed and screened $\frac{1}{8}''$	6 „

Water 10 to 13 gallons as required.

4. The mixing of the concrete for one pipe was done in four batches. The Medusa cement was first mixed with the sand dry, shingle added and then cement. This mixture was then wetted and thoroughly mixed and used at once in the pipe mould.

5. The pipes were made vertically. The mould consisted of an internal collapsible steel core. Around this the reinforcement (previously wound on a collapsible wooden drum made for the purpose) was placed concentrically and held in position by wedges at the top. The outside of the mould consisted of two semi-circular steel troughs bolted together by bolts passing through angle irons rivetted to the edges. Ramming was executed thoroughly by means of specially shaped iron and wooden rammers. The pipe thus made was kept wet for 36 hours when the collapsible core was removed. The pipe was then lowered into a horizontal position and covered with sacking which was kept wet until tested. Some of the pipes were filled with water.

6. For hydraulically testing the ends of the pipe were closed by means of iron plates drawn together by means of eight straining bolts outside the pipe. The joints were made water-tight by means of $\frac{3}{4}''$ Indiarubber packing and putty. By the above means perfectly water-tight joints were effected. Water was then poured into the pipe through a hole in one of the plate covers. A hydraulic test-pump was then attached and the pressure attained registered on a Bourdon gauge fixed to the pump. The best result was obtained with a pipe which withstood a pressure of

15 lbs. for 5 seconds. It appears, therefore, that reinforced pipes are not feasible. No test was made on any specially prepared waterproofing material except Medusa cement as it was deemed unwise to rely in any way on such devices; for though it might be possible to render a pipe water-tight for the present, it could not be said that such conditions would exist after the lapse of some years; to treat the pipes again with a waterproofing material after the pipes have been put in positions and joined up, would be practically impossible.

7. The appearance and finish of the pipes were excellent, thus proving the suitability of the concrete as regards its wetness and consistency at time of filling into the mould.

8. With this series of test pipes there has been one difficulty. Concrete best matures when absolutely submerged in water. This condition has not been possible in the head stores here. The pipes, however, have been given the best conditions available, namely, have been kept wet until ready for the hydraulic test. Slightly better results would probably have been obtained had it been possible to wholly immerse the pipes in water. There was a proposal to manufacture the pipes on the banks of the Shendi Nalla and roll them down and bury them in the wet sand of the nalla. This would have necessitated an enormous amount of excavation and it is doubtful if that would have been feasible when dealing with over 3,000 pipes. At any rate considerable expenditure would have been incurred on this account.

9. Another point which was not considered was that of expansion joints. Such joints would be required at about every 300 feet. Without special machines such a joint in reinforced concrete would be extremely difficult to make satisfactorily. The use of cast-iron expansion joints would have introduced the difficulty of joining cast-iron pipes to reinforced concrete pipes.

10. One of these pipes has been severely tested under a 10-ton steam roller and has been proved to be absolutely sound for use for cross-drainage works for roads.

Tabular statement showing results of hydraulic testing of reinforced concrete pipes.

No. of pipe.	Date when made, 1913.	No. of reinforcement.	Tested hydraulically in 1913.	Condition of pipe when tested.	Result of test.
1	August 13th	3	Novr. 3rd	Inner and outer surfaces cement washed and smooth.	Leaked badly, starting from bottom end and spreading all over, especially along circumferential reinforcement. Stood no pressure.
2	„ 16th	3	Do.	Do.	Leaked from top end downwards along longitudinal and circumferential reinforcement. Spouted at 4 places. Stood no pressure.
3	Sept: 5th	3	Novr. 4th	Inner surface cement washed, outer surface pitted.	Leaked from top downwards along longitudinal and circumferential reinforcement. Spouted badly at 2 spots. No pressure.
4	„ 11th	4	Do.	Inner and outer surfaces cement washed, outer surface hair cracked.	Leaked from centre outward with more leakage at bottoms than top. Spouted at 3 places. No pressure.
5	„ 16th	4	Do.	Inner and outer surfaces cement washed, outer surface rough.	Leaked longitudinally in centre and worked outwards. 3 bad spouts. Stood 15 lbs. for 5 seconds.
6	„ 18th	4	Oct. 27th	Outer surface smooth in patches, remainder pitted badly.	Leaked at bottom end upwards along longitudinal and circumferential reinforcement for ¾ length of pipe. No pressure.
7	„ 20th	4	„ 26th	Surfaces smooth, hair cracks outside which leaked.	Leaked at spot where 1st batch of filling ended (30″ from the bottom end) up to top of pipe along longitudinal and circumferential reinforcement. No pressure.
8	„ 23rd	4	Novr. 7th	Inner surface coal-tarred, outer surface smooth.	Leaked from top end downwards, longitudinal and circumferential along reinforcement. 3 spouts. No pressure.

Tabular statement showing results of hydraulic testing of reinforced concrete pipes—continued.

No. of pipe.	Date when made, 1913.	No. of reinforcement.	Tested hydraulically in 1913.	Condition of pipe when tested.	Result of test.
9	Sept. 25th	3	Novr. 6th	Inner surface coal-tarred, outer surface pitted in places.	Leaked badly all over especially along lines of longitudinal and circumferential reinforcing. Spouted in 4 places. No pressure.
10	,, 28th	4	Do.	Inner surface coal-tarred, outer surface very good.	Leaked from top downward along lines of reinforcing. Spouted in 4 spots. No pressure.
11	,, 30th	2	Do.	Inner surface coal-tarred, outer surface badly grooved where too liquid mixture has been squeezed out.	Longitudinal leak along groove, working from centre outwards along whole pipe length. 3 spouts stood 10 lbs. pressure for 2 seconds.
12	Oct. 4th	2	Do.	Inner surface cement washed, outer surface pitted in places.	Leaked from top downwards in one line along longitudinal reinforcing. Spouted in 4 places. No pressure.
13	,, 5th	1	Do. 5th	Outer surface pitted and grooved.	Leaked longitudinally from centre along one groove line. Stood 15 lbs. for 3 seconds.
14	,, 6th	2	Do.	Inner surface cement washed, outer pitted and grooved.	Leaked from top downwards and spouted in 2 places. Stood no pressure.
15	,, 8th	1	Do. 1st	Outer surface good but pitted in places.	Leaked from extreme top and worked downwards along longitudinal and circumferential reinforcing. No leakage over a large area. Stood 5 lbs. for 5 seconds.
16	,, 10th	1	Oct. 31st	Inner surface smooth and good, outer pitted.	Leaked almost entirely at upper $\frac{1}{3}$ of pipe along longitudinal and circumferential reinforcing. Spouted at 2 places. No pressure.
17	,, 13th	2	Novr. 2nd	Outer surface smooth but pitted in places.	Leaked from top end downwards $\frac{3}{4}$ length of pipe along longitudinal and circumferential reinforcement. Several bad spouts. No pressure.
18	,, 16th	2	,, 5th	Inner surface tar-washed 4 days previously, outer fair.	Leaked from top downwards longitudinally and circumferentially. 1 bad spout. No pressure.
19	,, 19th	1	,, 2nd	Inner and outer surfaces cement washed and smooth.	Leaked badly from top end downwards for $\frac{3}{4}$ length of pipe, also circumferential leakage near bottom. Spouted at 3 places. No pressure.
20	,, 21st	1	,, 2nd	Inner surface plastered with $\frac{1}{8}$th cement near outer surface fair, pitted in places.	Leakage started at extreme bottom of pipe and worked upwards along longitudinal and circumferential reinforcing and at pitting. 1 bad spout at bottom end. Stood 10 lbs. for 5 seconds.

PREVENTION OF WASTE IN WATER SUPPLIES.

BY

MR. C. H. WEST,

Sanitary Engineer to Government, United Provinces.

The water supplies in the larger cities in the United Provinces have during the last few years been a constant source of anxiety to the Municipalities concerned. During the summer months one town after another has found itself in difficulties owing to the demand exceeding the supply. None of these towns are provided with waste meter systems nor have they any means of detecting waste.

The question before us now is whether it would not pay us to spend comparatively small sums in metering these supplies and utilising properly the water at present available before spending large sums on increased supplies.

The following quotation from a paper read before the American Society of Civil Engineers conveys somewhat forcibly the opinion of the writer on the state of things prevailing in America at present. He says: "Perhaps the greatest folly of our time is the almost universal attempt of cities and towns to increase their water supply plant to keep pace with their waste. It is a hopeless task. It amounts to the same thing as attempting to fill a pail which has only a sieve at the bottom. The amount of water which can be used is limited. The amount which can be wasted has no limit."

The question of waste water prevention is one of the greatest importance to all Municipalities which have the care and upkeep of water-works in their charge. In places where the water-works have been in existence for the last 20 to 25 years and where the question of waste prevention has not been considered, the amount of water wasted is generally considerable. In Europe and America it has been estimated that the water wasted amounts to 30 to 70 p. c. of the total supply.

If Municipalities realized that large sums of money were being squandered on preventable waste, while they themselves were suffering from a shortage in their water supply, the question of waste prevention would receive much closer attention than it has hitherto received.

I think it can be safely said that there are few waste meter installations which have not justified their existence and paid for themselves both as regards capital, cost and maintenance. There comes a time in the life of all water-works installations when it becomes impossible to carry on without some organisations for waste detection and prevention.

If water were properly used, an average of 10 gallons per head would probably suffice for domestic consumption. The average allowance for a soldier in camp in Great Britain is 10 gallons. Twenty gallons is a fairly abundant average supply. Twenty-five will allow for a moderate amount for trade and manufacturing purposes, though for a purely manufacturing town more might be needed.

Slagg gives the consumption for an average town as follows :—

Drinking, cooking, washing	.. 10 gallons.
Offices, animals and carriages	.. 2 „
Baths, W. C.'s	.. 5 „
Factories, breweries and of public buildings, street watering and flushing	8 „
TOTAL	.. 25 gallons.

In London the consumption varies from 20 to 36 gallons a head. Norwich 11 gallons, Glasgow 45 gallons, Manchester 31 gallons, Liverpool 24 gallons. Berlin (fully metered) 16 gallons. In the United States the average of 137 towns gives 134 gallons a head, while the consumption in unmetered towns in America is often 4 to 5 times that in metered towns. The average in England is 25 and in Germany it varies from 11 to 28 gallons per head.

In the United Provinces the average daily and maximum daily consumption for the following towns is as follows :—

	Average.	Maximum.
Lucknow	8·11	14·89
Meerut	9·60	14·43
Allahabad	10·62	16·11
Agra	14·07	20·71
Cawnpore	17·85	27·28
Benares	22·64	31·20

It is generally found when the water is drawn from street standposts only the consumption can be kept down to 6 to 8 gallons per head, but as soon as house connections are put in in any large numbers the consumption jumps up to 20 to 25 gallons per head and more. It is generally in these small pipes for house connections that the bulk of the leakage and wastage takes place.

At present water is paid for in these provinces either by a water rate based on the rental value of a house or by a ferrule rate. When the basis of assessment is on the rental value, the man with a house connection pays exactly the same as a man with no house connection and uses considerably more water and very often the amount paid as water rate is not 1/10th of the value of the water consumed or wasted. In some towns there is no water rate and water is sold for house connections by a ferrule rate. Here also the charge made for the ferrule connection is based on the idea that the water will be used solely for domestic purposes and will not be wasted.

The system of ferrule rates as charged at Cawnpore is given below :—

(*a*)	½″	ferrule with	½″	pipe giving	2	gallons a	minute	@/8/ a	month.
(*b*)	¾″	ferrule	,,	,,	3	,,	,,	@/12/	,,
(*c*)	1″	ferrule	,,	,,	4	,,	,,	@1/4/	,,

The free allowance on (*a*) is 6,000 gallons a month, on (*b*) 8,000 and on (*c*) 12,000 gallons a month. Any quantities used in excess to be metered and charged at Re. 1 for 5,000 gallons. It will be seen that 2 gallons a minute is equal to 2,880 gallons in 24 hours, though the tax-payer is only entitled to 6,000 gallons a month. So the system of charging ferrule rates does not take into account the likelihood of waste and the cost of the free allowance of 6,000 gallons at 2·4 annas a thousand is more than -/8/- charged as a ferrule rate and does not take into account the likelihood of waste.

Anyone who has interested himself in water waste in these Provinces will know that in the Mahomedan quarters of a town there is very little water wasted, but in certain parts of the Hindu quarter and more especially in the quarter occupied by Bengalees there is a great deal of waste and in some parts it is nearly impossible to get people to turn off their taps and the noise of running water causes them no annoyance. I have personally come across numerous cases in which consumers through thoughtlessness have allowed their taps to get into a very bad and leaky condition and consequently these taps are constantly running. This is also done by otherwise well meaning people with the idea of flushing their drains. In some cases I have seen taps directly connected with W. C.'s by means of split bamboo channels. In other cases pieces of cloth are put over the pipe to deaden the sound of the running water and the water is allowed to flow constantly into the house drain. The discharge through an orifice of ½ sq. inch area with a 50 head is theoretically 4,417 gallons per hour. So it can be understood how soon an abundant water supply can be dissipated. In some cases even the Municipal standposts are not above reproach. It is extremely false economy to allow such a state of things to remain unattended to.

To illustrate my point, I will give you an instance of a case which has recently come under my notice at Benares. In making an inspection of the town I noticed that the sewers of one quarter of the town named Bengalee Tolah with a population of 25,000 were always running full and that they were carrying a great deal more water than they were intended to, while some seemed to be escaping down a large storm water drain. In order to check the water consumption in this part an experimental test was made. There were no meters and we could only check the water pumped at the pumping station. We first pumped water to the whole town of 200,000 inhabitants, keeping up a constant pressure at the pumping station and found we were pumping 6,000 gallons a minute to keep the head constant, later on when the time for which we normally supply water was over, we shut off the remainder of the town and pumped to Bengalee Tolah only and kept up exactly the same pressure at the pumping station. We found that the water being consumed in Bengalee Tolah was 3,000 gallons a minute. It will thus be seen that a small community of about ⅛th of the total population were consuming half of the whole supply for the town and being favourably situated on the main, the greater part of the town which lies beyond Bengalee Tolah got very little water with little or no pressure. By dividing the town of Benares into several waste meter districts we hope to get some control over this wastage, but though waste metering and house-to-house inspection may reduce wastage considerably, it is only by metering each individual house connection in a district like this that waste can be got under proper control. This question will be considered again later.

I will now deal with the waste meter system as proposed for Benares. The proposal is to divide the town into 30 entirely separate districts controlled by Deacon Meters. The whole supply for each district will pass through its own meter and the meter readings will show the day and night consumption for each district separately under ordinary working conditions without closing any sluice valves. It will

then be possible to tell by a glance at the records of the different districts where too much water is being used or where water is being wasted.

As regards the cost of metering, the average cost of these meters, excluding bulk meters on trunk mains for five towns in the United Provinces where meters have been proposed, works out to Rs. 136 per 1,000 inhabitants and Rs. 6·5 per 1,000 gallons supplied daily.

It generally costs more and is far less satisfactory to put in meters into an old system not designed for metering than in a new system which has been laid out with this object. As regards the saving in water which has been shown by such meters, it may be mentioned that in the case of 12 towns in Great Britain in which the average consumption for the lot was 31 gallons a head, the average reduction made was 9 gallons a head.

The actual cost of supplying 1,000 gallons of filtered water at Benares exclusive of interest and sinking fund charges on the plant is -/1/- per 1,000 gallons and with interest charges -/2/- per 1,000 gallons. If a saving of 10 p. c. is made on the present average consumption of 22·6 gallons a head, this means 2¼ gallons saved per head on 200,000 and at -/2/- per 1,000 gallons the value amounts to Rs. 20,000 a year or @ -/1/- to Rs. 10,000 a year. The extra charges for working the system are estimated @ 6,000 a year. So in any case there should be a substantial saving to the Municipality and more water should be available for legitimate demands with better pressure throughout.

Along with this system of waste detection by meters there will have to be a properly organised staff for house-to-house visitation and to repair and put right all defective fittings. All such work should be under Municipal control, but there is often great difficulty in India in getting permission to enter private premises and there is little doubt that the system of metering as many as possible of these private connections is the only way of doing away completely with waste at the consumer's end and ensuring that prompt notice of any defects in the fittings will be given by the consumers themselves.

A striking example of what can be accomplished by proper metering is given in the speech made by the Chairman of the London Hydraulic Company to the shareholders in 1891. They supply all consumers by meter and had the satisfaction of registering and receiving payment for no less than 96 p. c. of the water pumped by them.

When proposals for house metering are put forward they are always met by the old retort that the cost will be prohibitive. At present meters are put in if the hire -/8/- a month is paid on the smallest size of meter. Why could not this charge for hire and upkeep be included in the charge for water supplied through the meter ? At present at Cawnpore a ferrule rate of -/8/- a month entitles a man to a house connection and no further metering is done. If anyone who pays -/8/- monthly can get a ferrule connection the result will be financial ruination for the Municipality.

What I would propose is that the minimum water rate for a house connection should be 1/8/- a month including the rent of a meter at -/8/- a month and he should get his water at the rate of, say, 4,000 gallons per rupee. He would thus get 6,000 gallons for 1/8/- and pay for any excess at the same rate. Large consumers should be supplied at the same rate and the extra income obtained by raising the rate for water will provide a fund for the purchase and upkeep of meters. If the extra income so obtained were kept separate and untilised solely on metering, meters could be gradually introduced on all connections and waste would be entirely checked. Meters are much more efficient than any number of inspectors in promptly detecting waste, they not only detect waste but charge it to the consumers who are responsible. No consumer with a metered supply can afford to allow his fittings to get into bad order. If he did, his next quarterly bill would draw attention to the increased consumption and the defects would be put right. Even if wholesale metering cannot be undertaken, every meter put in means increased efficiency and economy and it is better to start with a few waste or house meters than not to start at all. Apart from efficiency metering is sound financially. Every meter put in means increased income to the Municipality.

The metering of supplies for domestic purposes has sometimes been opposed on sanitary grounds and sometimes for the reason that the revenues are likely to be reduced by supplying water through meters. Both these objections can easily be met by fixing the minimum water rate on any house by its rental value as at present and giving a liberal free allowance for this water rate equivalent to at least 15 gallons a head per day for domestic purposes to the maximum number who are likely to occupy the premises.

I have said nothing as regards the different types of meters or how waste meter systems are arranged and worked, as these are subjects on which every Sanitary Engineer has a certain amount of experience. What I would like, however, to impress on Municipalities is that if they cannot afford to waste-meter the whole of a Municipality at once, meter one or more districts where the surface drains or sewers

show the greatest flow per head and gradually take up other parts. To ascertain exactly what was being done in different parts of India in connection with waste prevention, a circular letter was drafted to all responsible Engineers asking them for the information required. Their replies are printed as an appendix to this paper, and I must thank them very much for the trouble taken in replying. In some of the replies suggestions for model bye-laws are given which are most useful as no water-works system can be properly worked without a good set of bye-laws. Almost of equal importance to good bye-laws is a good system of administering these and I would strongly recommend to all Municipalities a good system of card indexing as an invaluable aid in water-works administration in dealing with waste, stores, revenue collection, or, in fact, anything connected with water-works.

APPENDIX.

Copy of letter No. E-845, dated the 29th November, 1912, from W. B. MacCABE, Esq., M. I. C. E., F. I. C., Chief Engineer to the Corporation of Calcutta, to C. H. WEST, Esq., Sanitary Engineer to Government, United Provinces.

I have the honour to acknowledge receipt of your letter No. 1613/64, dated the 6th instant, and have to inform you in reply that the undermentioned measures have been adopted in Calcutta to prevent waste of water :—

Stopcocks have been fixed on all house connections in some convenient position in the road or footpath so that the supply to each premises may be under control at any hour of the day or night. The waste water meter system has been introduced throughout the Town and all connections made with the main are now controlled by 238 waste water meters, the majority of which are 6 inches diameter and the remainder 4 inches. Each of these waste water meters controls from 100 to 400 house connections and by means of night and day inspections with the assistance of the waste water meter, it is possible to ascertain the condition of each house connection.

A staff of 13 overseers, grade Rs. 65 to Rs. 80, and 66 Sub-Overseers, on grade Rs. 50 to Rs. 65, has been organised to work the system referred to above. The men when possible are received from the passed students of the Seebpore Engineering College.

In order to ascertain where excess water is consumed, a large number of house water meters are in use (at present there are 1,480 fixed) and in cases where the consumption is found to exceed 20 gallons per head and the quantity consumed is more than that permitted under the assessment of the premises, a charge for the excess is made and this charge has to be paid by the occupier of the premises.

The waste water meter system also affords means of proving the condition of service mains and if bulk meters are fixed they would in their turn prove the condition of the trunk mains.

The result of the campaign against waste has been to place mains and house fittings in a good state of repair and to provide means to show that they are maintained in such a state. Further, we have been able in a large number of cases to reduce the consumption where it was formerly excessive. Lastly, we have been able to maintain a high pressure and a practically continuous supply without providing an excessive supply of water.

In conclusion, I may say that although it is possible, with the means referred to above, to prove the condition of house fittings, pipes, and water mains generally, experience in the last teaches us that unless some restriction is placed upon the consumption it is impossible to keep it within reasonable bounds. For this reason if house connections are freely allowed and little or no restriction placed upon the number of taps fixed, by far the best course is to arrange at the outset to fix meters on all connections and charge accordingly.

Copy of a letter No. 2041, dated the 9th December, 1912, from G. B. WILLIAMS, Esq., Sanitary Engineer, Bengal, to the Sanitary Engineer to Government, United Provinces.

With reference to your letter No. 1609/64 of the 6th ultimo, enquiring what steps are being taken in this province to prevent the waste of filtered water in all the Municipalities having water-works, I have the honour to forward herewith a copy of the model rules for private house connections drawn up by the Government of Bengal, and to say that pressure is being brought upon all the Municipalities having filtered water supplies to adopt these. It is particularly desired to insist on meters being made obligatory on all private house connections, and also on charging for extra water on an incremental scale. Waste from street standposts is being checked by the introduction of automatic self-closing taps.

Model Rules for the grant to private premises of house connections for domestic purposes in connection with a filtered water-supply.

1. So long as the Commissioners deem it practicable and consistent with the maintenance of an efficient water-supply, they may allow any owner or occupier of a masonry building paying a water-rate imposed under the provisions of Part VII of the Bengal Municipal Act, 1884, on the annual value of such building, when such annual value is not less than Rs. , to lay down communication-pipes from the service-pipes of the Commissioners for the purpose of leading water to such building for domestic purposes only, subject to the following rules and conditions.

2. The owner or occupier of any masonry building requiring water to be laid on to such building for domestic purposes, or requiring any addition or alteration to an existing water-supply, must apply for the same on a printed form to be supplied free of cost at the Municipal office.

3. A fee of Rs. must be paid to the Commissioners by such owner or occupier for each building connection before any work is commenced, such fee to be in addition to all other costs and charges imposed under these rules.

4. Each building must have a separate connection, and extensions from the communication-pipe of one building to another shall not be permitted.

5. The owner or occupier of the building, in respect of which the connection is required, must pay the entire cost of the connection, including the supply and fixing of the fittings referred to in rule 7, and must also pay the cost of such alterations in, or repairs to roads, drains, sewers, gas or water-mains or pipes, and the cost of such other works, as may be necessitated by, or result from, the work of making such connection.

6. (1) The work required may, at the option of the Commissioners, either be carried out by the Commissioners themselves at the expense of the owner or occupier of the building in respect of which the work is required, or may be carried out by a person or firm employed by such owner or occupier and approved by the Commissioners.

(2) The work must be done under the supervision of an officer appointed by the Commissioners in this behalf, and no connection must be made with the Municipal water-main except at such time as may be appointed, and in such position as may be selected, by an authorised Municipal officer.

7. A building connection shall comprise the following parts or fittings :—

(*a*) a brass or gun-metal ferrule inserted in the main supply-pipe;
(*b*) a galvanized iron communication-pipe from the ferrule to the meter;
(*c*) a stop-cock and its surface-box;
(*d*) a meter;
(*e*) service pipes from the stop-cock to the taps; and
(*f*) taps.

8. (1) All the fittings referred to in rule 7 shall be exact duplicates of standard samples kept in the office of the Commissioners, and approved by them in meeting.

(2) All fittings shall be inspected and tested and stamped by an officer of the Municipality before being fixed.

(3) If any owner or occupier shall desire to adopt any fitting of a pattern different from the standard patterns, he must present such fitting for the approval of the Chairman, and any fittings so presented may, if considered satisfactory by the Chairman, be stamped, and samples thereof may be purchased and placed among the standard fittings.

9. The size of the ferrule referred to in clause (*a*) of rule 7 shall be decided by the Commissioners, but its diameter shall not differ from that of the communication-pipe referred to in clause (*b*) of that rule by more than $\frac{1}{4}$ inch.

10. (1) The diameter of the communication-pipe shall be determined with regard to the average pressure in the main supply-pipe at the point nearest the building for which a connection is required, and to the quantity of water to be supplied.

(2) The diameter of the communication-pipe shall be such that it will be capable of delivering the estimated daily supply in six hours.

(3) The building connection, when fitted in position, must be capable of standing a pressure of feet, and no water shall be supplied until this test has been applied by the Commissioners.

11. (1) On every communication-pipe a brass or gun-metal stop-cock having the same waterway as such pipe shall be placed as near as practicable to the point where that pipe enters the building to be supplied.

(2) The stop-cock shall be built in a brick chamber provided with a cast-iron surface cover-box so designed that it can be locked, and the key of this box shall remain under the control of the Chairman.

(3) The stop-cock shall be capable of adjustment so that the supply to the building may be regulated thereby.

12. (1) The meter shall be placed as near to the stop-cock as possible and in a position where it can be conveniently examined.

(2) The meter must be fixed in a brick chamber covered over with a cast-iron surface-box of approved pattern.

(3) Subject to the provisions of rule 13, no meter must be touched or interfered with in any way except with the permission of the Chairman.

13. The Commissioners shall depute an authorised person to read every meter not less than once a quarter, and shall give notice to the occupier at least twenty-four hours before the reading is recorded.

14. (1) Every owner or occupier of any building in respect of which a connection has been made under these rules shall be entitled to a supply of gallons of water per quarter for each rupee paid by him as water-rate in respect of such building.

(2) For all water in excess of the amount allowed under sub-rule (*1*) such owner or occupier shall be charged quarterly as follows :—

	Annas per 1,000 gallons
(*a*) For any excess quantity of water not exceeding one-half of the amount of the free allowance	
(*b*) For any excess quantity of water exceeding one-half of the amount of the free allowance, but not exceeding the amount of the free allowance	
(*c*) For any excess quantity of water exceeding the amount of the free allowance, but not exceeding twice that amount ..	
(*d*) For any excess quantity of water exceeding twice the amount of the free allowance	

15. If the owner or occupier of any building which is supplied with water under these rules shall refuse or neglect to pay any of the fees or charges imposed in accordance with these rules for a space of fourteen days after he has been served with a notice of demand for the same the Commissioners may, at any time after the expiration of that period, and without further notice, disconnect any pipe forming part of the connection made in respect of such building and may recover the cost of disconnecting such pipe from such owner or occupier :

Provided that the disconnection of such pipe shall not relieve any person from any liabilities which he may have incurred under these rules.

16. (1) Every tap shall be of the same size as the pipe to which it is attached, and shall be of brass and of the pattern known as screw-down. Every tap shall be at least three feet above the road level.

(2) The number of taps in a building shall be fixed in accordance with the annual valuation of such building, as follows :—

Annual valuation of building.			Number of taps.
	Rs.	Rs.	
Under	300	.. ..	1
From	300 to	499	2
From	500 to	1,500	3
Above	1,500	.. ..	4

MUNICIPAL DEPARTMENT.

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MUNICIPAL.

Circular No. 30 M.

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CALCUTTA, THE 1ST APRIL 1911.

FROM

H. WHEELER, ESQ., C.I.E., I.C.S.,

Secretary to the Government of Bengal.

To

THE COMMISSIONER OF THE DIVISION.

SIR,

WITH reference to Section 290 of the Bengal Municipal Act, 1884, which empowers the Commissioners of a Municipality having a filtered water-supply to allow the owners and occupiers of holdings who pay a water-rate to lay down

communication-pipes from the service-pipes of the Commissioners for the purpose of leading water to their premises for domestic purposes, subject to such rules and conditions as the Local Government may make and impose, model rules have been framed on the subject and are circulated herewith, for the guidance of Municipalities concerned. These should be adopted as a standard by those Municipalities in your division which may in future make new rules or revise their existing rules on the subject, and while it is not obligatory that the model rules should be followed absolutely in all cases, irrespective of local conditions, it should be impressed upon local bodies that the rules embody the conditions which the professional advisers of Government consider to be suitable, and any departure from them should be fully justified.

I have the honour to be,

Sir,

Your most obedient servant,

H. WHEELER,
Secretary to the Govt. of Bengal.

Copy of a letter No. F-2013, dated the 14th November 1912, from A. S. MONTGOMERY, Esq., Sanitary Engineer to Government, Punjab, to the Sanitary Engineer to Government, U. P.

With reference to your letter No. 1612/64, dated the 6th November 1912, I have the honour to state that on the suggestions of the Sanitary Engineer, the Municipal Committees with Water Works in this Province have taken one or the other of the following measures to prevent wastage of water, to such extent as they have been able with reference to the state of their funds :—

I. Fixture of meters to public and private connections on the pipe mains.
II. Appointment of a special man to see that the standposts, valves and other fittings are in order.
III. Provision of self-closing cocks to standposts.

Copy of a letter No. D-180, dated the 2nd December 1912, from N. BELVADI, Esq., Sanitary Engineer to Government, Bombay, Poona, to the Sanitary Engineer to Government, U. P.

I have the honour to acknowledge receipt of your No. 1611/64, dated the 6th November 1912, and in reply to say that mofussil Municipalities in this Presidency having Water Works have, so far, not made any serious attempt to check the waste of filtered water. The fixing of meters to every house connection is beyond the means of Municipalities and the utmost that they can do at present is to send round Inspectors to see that house connections are not being misused and to have leaky taps repaired, and I need hardly say that this check is not very effective in preventing waste of water.

2. The Bombay Sanitary Board is giving considerable attention to this question and is now insisting on all Municipalities limiting the size of house-connections to half-inch diameter pipes, as a rule, and three-fourths inch connections are allowed in special circumstances only. All supplies from connections exceeding three-fourths of an inch will be metered and special rates will be charged for such supplies. The Board is also contemplating the introduction of district meters and experimental meters to check the total consumption of water in each ward and property and on the detection of waste by the Deacon's waste water meter system. Self-closing waste-not-taps made by Tyler and Sons and Lord Kelvin's screw-down bib taps will also be gradually introduced.

3. (*a*) In Bombay City the Water Works Department has recently employed a special establishment for the purpose of preventing waste of misuse of water. This staff is engaged solely on the detection or waste by the Deacon's waste meter system from water mains and house services.

(*b*) All the underground portions of private house service connections from the Municipal water mains have been taken charge of and are now kept in order and looked after by the Municipality.

(*c*) All pipes and fittings used for private supplies are required to be of special heavy quality and to undergo a severe test before they are allowed to be connected with any Municipal water main.

(*d*) In chawls and public places where water is likely to be wasted, the introduction of self-closing waste-not-taps is being enforced.

(*e*) Experimental meters are fixed to various properties from time to time to ascertain whether any misuse of water is taking place and all proper-

ties with gardens and places where large quantities of water are likely to be used such as trades, railways, Port Trust, &c., are charged water rates on meter measurement. The storage reservoirs within the City are being thoroughly overhauled and rendered watertight.

Copy of a letter No. G-13064, dated the 10th January 1913, from the Executive Engineer, Bombay Municipality, to the Sanitary Engineer to Government, United Provinces.

RE: PREVENTION OF WASTE OF FILTERED WATER.

With reference to your No. 1905, dated the 21st December 1912, I have the honour to forward herewith copies of the correspondence marginally noted passed between the Sanitary Engineer to Government, Bombay, and the Hydraulic Engineer of this Municipality on the subject for information.

* * * * *

Letter No. 1240 of 4th December 1912, from the Hydraulic Engineer, to the Sanitary Engineer to Government, Bombay.

Copy of letter No. 12401-W., dated the 4th December 1912, from the Hydraulic Engineer to the Sanitary Engineer to Government, Bombay.

With reference to your No. 3689 of 16th November 1912, I have the honour to inform you that with a view to preventing the waste of water in Bombay, this department has recently employed a special establishment for the purpose. This staff is engaged solely on the detection of waste by the Deacon's waste water meter system, from water mains and house services.

All the underground portions of private house service connections from the Municipal water mains have been taken charge of and are now kept in order and looked after by the Municipality.

All pipes and fittings used for private supplies are required to be of special heavy quality and to undergo a severe test before they are allowed to be connected with any Municipal water main.

In chawls and public places where water is likely to be wasted, the introduction of self-closing waste-not-taps is being enforced.

Experimental meters are fixed to various properties from time to time to ascertain whether any misuse of water is taking place and all properties with gardens and places where large quantities of water are likely to be used, such as trades, railways, Port Trust, &c., are charged water tax on measurements. The storage reservoirs within the City are being thoroughly overhauled and rendered watertight.

As regards the most suitable taps for Bombay, the " Tyler's patent self-closing waste-not-taps " is found to give entire satisfaction and also the Kelvin's screw-down bib tap.

Copy of a letter No. 239M., dated the 25th January 1913, from the Sanitary Engineer to Government, Madras, to the Sanitary Engineer to Government, United Provinces.

I have the honour to inform you that the wastage of filtered water to which our attention is at present directed is in connection with the indiscriminate granting of house connections to all and sundry without regard to the amount of water-rate paid by house-owners.

2. We have now got Municipal Council to adopt bye-laws for regulating consumption and a resolution for fixing a minimum charge for water used beyond the free allowance. A copy of the bye-laws is attached and in this connection I am taking steps to have the houses with a rental of Rs. 100 and less and a free allowance of 80 gallons removed from the scale.

3. As it is impossible to make any charge for excess water unless the amount is known, it is necessary to fix meters on house connections. It is not in my opinion advisable on financial grounds and not in many cases necessary to insist on meters being fixed on every house connection. It will suffice, I think, if we contemplate fixing meters to the extent of 20% of the number of connections, but we must have power under the Municipalities Act to fix meters to any or every connection.

4. Under our present powers we are unable to charge the house-owner for the cost of the meter. This, I think, should be altered, as in any case the charging of the cost of a meter to a house-owner who applies for a new connection would mean the withdrawal of the application for the connection. I think when the Act is next amended this power to charge for the cost of the water should be given to the Councils in the case of new house connections.

5. A suitable charge for excess water used for domestic purposes may be taken as on an average 12 annas per 1,000 gallons and for non-domestic purposes subject to safeguards Re. 1-8-0 per 1,000 gallons.

G. O. No. 109*M.*, *dated* 24*th January* 1911.

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

Read—the following papers :—

Memorandum No. 3985-I. M., dated 14th February 1910.

The Water Works bye-laws proposed by the Municipal Councils of Ootacamund, Kurnool and Gudiyattam, and those submitted by the Sanitary Engineer with his letter No. 2969, dated 25th September 1909, are forwarded to him, with the request that he will submit a draft of such bye-laws as he may now consider necessary under the revised provisions of the District Municipalities Act, 1884, as amended by Act V of 1909.

(Sd.) L. M. WYNCH,
Ag. Secretary to Government.

To the Sanitary Engineer.

Letter—FROM W. HUTTON, ESQ., A.M.I.C.E.,
SANITARY ENGINEER TO GOVERNMENT, MADRAS.

TO—THE SECRETARY TO GOVERNMENT,
LOCAL AND MUNICIPAL DEPARTMENT.

No. 2156, *dated the* 29*th June* 1910.

In reply to Memorandum No. 3985-I. M., dated 14th February 1910, forwarding to me the bye-laws proposed by the Municipal Councils of Ootacamund, Kurnool and Gudiyattam and those submitted by myself, I have the honour to say that I consider that the bye-laws proposed by the Ootacamund Council, which appear to be copied from the Simla Water Works bye-laws, should be adopted by all Councils under the new provisions of the District Municipalities Act.

2. These bye-laws which I recommend require slight alterations and these alterations have been carried out in the copy of bye-laws attached.

3. The enclosures to the above memorandum are herewith returned.

BYE-LAWS

WATER SUPPLY.

The following bye-laws are laid down for the proper regulation of the Water Supply and appurtenances :—

(1) No person shall use, for the purpose of bathing, washing or human consumption, the water of any public well, tank, spring or stream, within Municipal limits, after the Municipal Council has, by public notice, declared the said water to be unfit for the use of man until the said declaration shall be similarly cancelled.

(2) Except in the case of fire, no person not duly authorised by the Municipal Council in that behalf shall, within Municipal limits, open or in any way interfere with any main or pipe or valve or fire plug connected with the Municipal water supply.

(3) No person shall wilfully use the water from a standpost to run to waste and every person using the standpost shall turn off the water.

(4) No person shall use the standposts, or public taps, or fire plugs with the object of securing a supply of water by continuous flow for any purpose except for the extinction of fire. The person for whose advantage or benefit such water has flowed shall be considered to have used water in contravention of this bye-law.

(5) No person shall use the standposts for the washing of cloths or for the cleaning of utensils, or for bathing purposes of himself or any other person or for bathing animals.

(6) No person shall, without the express permission of the Municipal Council in writing, use water derived from the standposts or public taps, or fire plugs for any building operations or for the purpose of any manufactory.

(7) The Municipal Council shall limit the supply of water that may be taken from the pipe service, as a return for the water tax paid, whenever they consider it necessary so to limit it. Such limit shall be fixed according to the following table :—

House Rental per annum.	Daily allowance in gallons.
Rs. 100 to 400	100
„ 400 to 700	120
„ 700 to 1,000	180
„ 1,000 to 1,500	200
„ 1,500 to 2,000	220
„ 2,000 to 2,500	260
„ 2,500 to 3,000	300
„ 3,000 and above	350

NOTE.—When vacancy refund of water tax is claimable, half of the quantities fixed will be given.

(8) The Municipal Council may impose a charge not exceeding Rs. 3 per 1,000 gallons or fraction thereof, for water taken in excess of the limit prescribed in the last preceding bye-law. In computing this charge, credit will not be given in succeeding months for any less quantity consumed during a previous month.

(9) In addition to the charges referred to in the last preceding bye-law, the Municipal Council may impose a special charge for the use of water permitted to be taken for trade or other non-domestic purposes. Such special charges shall be calculated by bulk, and in proportion to the water supplied by such use as aforesaid, and subject to the condition that such supply may be cut off at any time should the supply for domestic purposes in the town be deficient.

(10) It shall be within the discretion of the Municipal Council to allow any person not residing within the limits of the Municipality to take or be supplied with water for domestic purposes on such terms as the Municipal Council at a meeting thereof may from time to time prescribe. And any person taking or causing to be taken for use outside the limits of the Municipality water supplied by the Municipal Council, without the permission of the Municipal Council shall be liable to prosecution before a Magistrate.

(11) The Municipal Council may at their discretion cut off the water from any house, premises or land connected with the pipe service under private contract as a penalty for non-payment of the special charges under which such water is supplied and no connection thus cut off will be re-established except on payment of (*a*) all arrears due of the special charges aforesaid, and (*b*) a penalty not exceeding Rs. 10.

(12) The Municipal Council may at their discretion cut off the water from the mains during certain hours of the day or night, whenever such a course is deemed necessary on account of deficient supply from the head works, by reason of destruction of the pipe line or on account of repairs, or by reason of an accident, the result of an act of God or any other cause.

HOUSE-CONNECTIONS.

(13) Each house to which water is laid on shall be provided with a separate service pipe connection, a stop-cock and whenever the Municipal Council so decide, with a meter. And no house will be supplied with water from the service connection of any adjoining house or premises.

NOTE.—No house assessed on an annual rental below Rs. 100 will be allowed a separate service.

(14) The diameter of the service and communication pipes and the number, size and kind of stop-cocks or taps and meter shall in all cases be determined by the Municipal Council. No service pipe shall be larger than one inch.

Ordinarily the number of taps to be allowed to a private house or premises will be as follows :—

Assessed annual rent.	Number of taps allowed.
Rs. 100 to 300	1
,, 300 ,, 600	2
,, 600 ,, 900	3
,, 900 ,, 1,200	4

(15) All piping shall be galvanised and unless otherwise specified by the Municipal Council, be capable of withstanding a pressure equal to 260 feet of water.

(16) All fittings and materials used in house-connections shall be inspected and approved by the Municipal Council or such officer as may be empowered by it in that behalf.

(17) All work connected with a private connection shall be executed in such a manner as the Municipal Council may, by order in writing, direct and the work shall only be carried out by such person or persons as may be, from time to time, authorised by the Municipal Council on that behalf.

(18) No person other than a Municipal official or other person duly authorised by the Municipal Council in that behalf shall open, cut off, or in any way interfere with any water connection or communication with any of the municipal water mains, or with such water mains themselves, or with any reservoir, hydrant, tank, valve or any other fitting or break, injure, open any lock, cock, valve, pipe-work or engine appertaining to any water work or wilfully do any act whereby the water in any pipe or other water work may be contaminated or wasted.

(19) No new connection or alteration to an existing connection shall be made without the written permission of the Municipal Council and such connections or alterations may only be made by such person or persons as are authorised by the Council in that behalf.

(20) Any owner or occupier of any house, land or premises with which any connection or communication with any water main has been established who wilfully or negligently omits to report, within 24 hours, to the Municipal Council any damage or leak happening or appearing in any such pipe connection or communication shall be deemed guilty of a breach of this bye-law.

(21) All pipes, stop-cocks, meters and other fittings of a water connection shall be under the control of the Municipal Council.

(22) It shall be at the option of the Municipal Council to provide water for latrines, privies, urinals and water closets, and it shall be lawful for the said council to require that all latrines, privies, urinals and water closets so supplied with water shall be provided with a cistern of such size and description as the Municipal Council may, in writing, direct, and all such cisterns shall be provided and fixed at the cost of the owner of the premises so supplied with water.

(23) Every boiler for generating steam shall be supplied with water from a cistern and not directly from the service pipe, and every cistern shall be supplied with a meter, a ball-valve, a detective or warning pipe and proper means of access for inspection thereof.

METERS.

(24) When a meter is supplied with water connection, an annual rent to cover cost of its supply and maintenance shall be payable by the owner or occupier of the house or premises or land. This rent will be in addition to the water tax levied under section 75 of the Madras District Municipalities Act, and the cost of the connection and arrears shall be recoverable, if necessary, under sections 103 and 269 of the said Act.

(25) All meters when deemed necessary, will be provided by the Municipal Council and fixed by them in such positions as they shall determine ; but the cost of fixing, including the necessary ferrule, pipe from the main and stop-cock, all of which will be supplied and fixed by the Municipal Council, shall be paid by the owner of the premises so connected.

(26) The Municipal Council will not be responsible for any stoppage, deficiency or want of supply arising from drought or other unavoidable cause or accident.

(27) All meters will be maintained and repaired to the extent of ordinary wear and tear by the Municipal Council and the charge therefor will be included in the rent payable by the owner or occupier as provided in bye-law No. 24.

(28) The cost of repairs necessitated by injury from fire or accident caused by the negligence of the owner or occupier or by their servants or any other person or persons not being Municipal servants shall be paid by such owner or occupier. The cost of any repairs rendered necessary by reason of faulty material employed or defective construction will be defrayed by the Municipal Council. All repairs shall be executed by, or under the direction of, the Municipal Council.

(29) All meters shall be under the sole control of the Municipal Council and access thereto at all reasonable times shall be afforded to any officer or officers duly authorised by the Council in writing in that behalf.

(30) The Municipal Council may at any time remove any meter for the purpose of testing its accuracy or for examination or repair or in order to substitute another for it, and also in case of the discontinuance of the water supply.

(31) The consumer may request the Municipal Council to test his meter should he dispute its registration. The cost of testing must be borne by the consumer should the meter prove to be less than 5 per cent. fast. But should it be 5 per cent. or more fast, the cost of the test will be borne by the Municipal Council and the ascertained overcharge refunded *pro rata* for the preceding two quarters. The charge for testing shall not exceed 5 per cent. of the cost price of the meter.

(32) No person shall wilfully or by culpable negligence injure or suffer to be injured any pipe forming a communication or connection, meter or fitting belonging to the Municipal Council or fraudulently alter the index to any meter, or prevent any meter from duly registering the quantity of water supplied, or fraudulently abstract or use water belonging to the Municipal Council.

(33) Any one committing a breach of any of the foregoing water supply bye-laws shall be liable to a fine not exceeding Rs. 20.

III

Memorandum No. 2683—*I. M., dated* 18*th November* 1910.

IV

Letter from W. O. DAVID, Esq., Government Solicitor, Madras, to the Secretary to Government, Local and Municipal Department, dated the 23*rd December* 1910.

No. 1619.

ORDER—No. 109-M., dated 24th January 1911.

The Government have examined in detail the water works bye-laws submitted by the Sanitary Engineer with his letter No. 2156, dated 29th June 1910, as well as

those already in force in the several Municipalities. Such of them as were found either unnecessary or inconsistent with the provisions of section 147 of the Madras District Municipalities Act, 1884, as amended by the Madras District Municipalities Act Amendment Act, 1909, have been expunged or modified and the bye-laws as finally revised are appended to this order. The draft submitted by the Sanitary Engineer overlooks the amendments made in the law in 1909 and for this reason, among others, has been found to require considerable alteration.

2. The bye-laws as now revised will be circulated to Municipal Councils having water-works with the request that they may be published in the " Gazette " of the district concerned in the manner required by sub-section (1) of section 256 of the Act. After the lapse of the period specified in the notification publishing them, their final adoption should be formally considered and the result reported to Government in order that the revised bye-laws may be approved and confirmed under sub-section (3) of section 255.

3. Under sub-section (1) of section 147 of the Act, it is for the Chairmen of Municipal Councils to decide the quantity of water to be supplied for domestic purposes with reference to the annual rateable value of buildings or otherwise. For water taken in excess of the limit allowed under this sub-section payment should be required at rates to be prescribed by the councils under sub-section.

The Government consider that a general scale by which to determine the supply of water for domestic purposes on the basis of the annual value of the buildings supplied will be of some assistance to Chairmen and they accordingly suggest the following standard subject to such variations as local conditions may require :—

House of the rental value per annum of							Daily allowance in gallons.
Rs.	100 and less	..	..	..	..	..	80
Above	100 up to 400	..	..	..	..	..	100
„	400 „ 700	..	..	..	..	..	120
„	700 „ 1,000	..	..	..	..	..	180
„	1,000 „ 1,500	..	..	..	..	..	200
„	1,500 „ 2,000	..	..	..	..	..	220
„	2,000 to 2,500	..	..	..	..	..	260
„	2,500 „ 3,000	..	..	..	..	..	300
„	3,000	..	..	..	..	..	350

4. It would also seem expedient to regulate the number of taps to be allowed in private premises according to some definite principle. If the supply of water available is sufficient, the Government would advise an allowance of one tap for houses with a rental value of Rs. 300 and less and an extra tap for every additional Rs. 300 of rental value or fraction thereof up to a maximum of four taps.

(True Extract).

(Sd.) L. DAVIDSON,
Ag. Secretary to Government.

To all Chairmen of Municipal Councils (through the Collectors concerned),
„ the Sanitary Engineer (through the Public Works Department).

APPENDIX.

Model bye-laws connected with water works.

Every application for the supply of water under sub-sections (1) and (2) of section 147 shall be made to the Chairman in writing signed by the applicant and so far as may be in Form A hereunto annexed, and the work necessary for such supply shall not be commenced until the applicant has deposited the estimated cost of carrying it out with the municipal council. The estimate will be fixed by the Chairman and if he thinks fit, he may prescribe a time within which the deposit shall be made.

2. Each house to which water is laid on shall be provided with a separate service pipe connection and stop-cock. And no house will be supplied with water from the service connection of any adjoining house or premises.

3. The diameter and character of the service and communication pipes and the number, size and kind of stop-cocks or taps shall in all cases be determined by the Chairman.

4. The Municipal Council may by general or special order direct that any private latrine, privy, urinal or water closet which is supplied with water from Municipal Water-Works shall be provided with a cistern of such size and description as it may prescribe.

5. Every boiler for generating steam which requires water from a municipal source shall be supplied with water from a cistern and not directly from the service

pipe, and every such cistern shall be supplied with a ball-valve, a detective or warning pipe and proper means of access for inspection thereof.

6. The Chairman may at any time remove any fitting connected with the water-works for the purpose of examining its condition or for repair.

7. No person shall wilfully or negligently allow the water from a standpost to run to waste.

8. No person shall use the water from the standposts for the washing of clothes, animals or vehicles or for bathing purposes.

9. No person shall without the express permission in writing of the Municipal Council, use water derived from the standposts or public taps or fire plugs for any building, gardening or agricultural operations or for the purpose of any manufactory.

10. No person shall so manipulate the standposts or public taps, or fire plugs, as to secure a continuous flow of water for any purpose except for the extinction of fire.

11. Except in the case of fire, no person not duly authorized by the Municipal Council in that behalf shall within municipal limits open or in any way interfere with any main or pipe valve or fire plug connected with the municipal water supply.

PENALTY.

Whoever commits a breach of any of the bye-laws Nos. 7 to 11 shall be liable on conviction to a fine not exceeding Rs. 20 and in case of continued infringement shall be liable on conviction to a further fine not exceeding Rs. 10 per diem for every day on which after the date of first conviction and after notice from the Municipal Council of such infringement he is proved to have repeated the offence.

ANNEXURE.

FORM A.

To

THE CHAIRMAN,
Municipal Council,
.....

I, the $\frac{\text{owner}}{\text{occupier}}$ of the undernoted building, hereby request that you will arrange to supply me with water for domestic purposes $\frac{\text{or}}{\text{and}}$ for non-domestic purposes in house No. in street . The non-domestic purpose referred to is and the quantity of water likely to be consumed for such purpose is gallons per diem. For water taken for domestic purposes in excess of the limit allowed under section 147 (1), and water used for non-domestic purposes, I agree to pay at such rate as may be fixed by the Municipal Council under section 147 (3). In the event of my desiring to terminate the contract for the supply of water herein provided for, I undertake to give notice in writing to the Chairman to that effect.

NOTES ON COMPARATIVE COST OF PUMPING AT VARIOUS WATER-WORKS IN THE CENTRAL PROVINCES.

BY

MAJOR L. W. S. OLDHAM, R.E.,

Sanitary Engineer to Government, Central Provinces.

AT the Madras Sanitary Conference of 1912 a resolution was passed by the Engineering delegates suggesting that information be collected and tabulated regarding the cost of pumping in connection with municipal water supplies in India.

The following notes are an outcome of this resolution :—

In the Central Provinces the technical side of municipal water supplies is under the supervision of the Public Works Department, and though the actual method of administration varies in different cases, records of maintenance figures that may be relied on are kept up for all water-works.

There are in the Central Provinces and Berar eight water-works, the supply of which is either partially or wholly dependent on pumping.

The population served varies considerably from 72,000 in Nagpur, to under 4,000 in Buldana. Similarly the pumping plant in use comprises a varied assortment of machinery, old and new, horizontal and vertical, and varying in size from two 100 h.p., triple expansion steam-engines at Nagpur, to a 9 h.p. oil engine and three-throw pump at Buldana.

The unit adopted for purposes of comparison is the pump horse-power, measured in water actually raised. The time taken is one hour for purposes of fuel consumption and cost incurred.

The figures deduced of coal consumption and duty are the actual results of twelve months' working, and are necessarily very different from the figures that would be obtained in a trial over a short period of time. They are also perhaps more interesting for purposes of comparison, and from the point of view of water-works administration.

The deduced figures for consumption of fuel and for duty, if the best English coal had been used, are based on co-efficients contained in Government of India Circular No. XIV-Railway, dated the 7th December 1904.

The values assigned to coal from coal-fields and collieries not mentioned in the circular, have been arbitrarily fixed on a general comparison of quality only, and not from the results of special tests of their calorific values.

These notes are of little general interest except perhaps to other water-works engineers in this country. This paper will, however, have served its purpose, if it is the means of eliciting similar figures for water-works in other provinces.

The author especially hopes that the results of experience gained in the use of oil engines of the Diesel and Semi-Diesel types will be communicated to the Conference, not only as regards fuel economy but also the more general question of—

Cost of maintenance.
Reliability.
Skilled staff required, etc., etc.

NAGPUR WATER-WORKS.

Specification of Pumping Machinery at Gorewara Station.

Engines.—Two horizontal direct acting triple expansion surface condensing Worthington's Pumping Engines, each 100 p.h.p. with attached feed pumps. Each engine is capable of discharging 1,500 gallons per minute, against a head of 220 feet, including friction. The leading dimensions of each engine and pump are as under :—

High pressure cylinder	...	...	...	10″ diameter.
Intermediate ,,	...	...	...	16″ ,,
Low pressure ,,	...	...	...	25″ ,,
Pump plungers	...	...	...	13½″ ,,
Stroke ...	...	...	...	18″ ,,

The suction pipe is 18″ diameter. The delivery pipe from the pump to its junction with 18″ rising main is 14″ diameter.

Boilers.—Tubular Babcock & Wilcox Boilers in duplicate with superheaters and economiser of Green's type fitted with scrapers.

Two Worthington independent feed pumps :—

Steam cylinder	5½″ diameter.
Water plungers	3½″ ,,
Stroke	5″ ,,

The above were manufactured, supplied and erected by Messrs. James Simpson & Co. The cost of the engines and boilers was Rs. 1,23,400.

NAGPUR WATER-WORKS.

Specification of Pumping Machinery at Old Nagpur Pumping Station.

Now re-erected at Gorewara Pumping Station.

New Engines.—Horizontal direct acting triple expansion surface condensing Worthington's Pumping Engine of 47 p.h.p., capable of discharging 750 gallons per minute, against a head of 209 feet, including friction. The leading dimensions of engine and pump are as under :—

High pressure cylinder	8″ diameter.
Intermediate ,, ...	12″ ,,
Low pressure ,, ...	20″ ,,
Water plungers	10″ ,,
Stroke	15″ ,,

The suction pipe is 12″ diameter. The delivery pipe from the pump to its junction with the rising main is 10″ in diameter. These were manufactured and supplied by Messrs. James Simpson & Co.

Boilers.—These are of the multitubular locomotive type in duplicate, each being 30 n.h.p. The extreme length is 16′-5″ ; diameter 4′-4″, weight 8½ tons.

Two Worthington's externally packed Ram Feed Pumps, size $4\frac{1}{2}'' \times 2\frac{3}{4}'' \times 4''$ to supply feed water to the boilers. The cost of engine alone was Rs. 43,886.

WARDHA WATER-WORKS.

Specification of Pumping Machinery at River Pumping Station.

Pumping Engines.—There are two horizontal Worthington's Compound Non-condensing Pumping Engines, each capable of discharging 200 gallons per minute, against a head of 239 feet including friction, with a steam pressure of from 70 to 80 lbs. per square inch on boiler. The leading dimensions of each engine and pump are as under :—

High pressure cylinders	8″ diameter.
Low pressure ,, ...	12″ ,,
Water plungers	6″ ,,
Strokes	10″ ,,

The suction and delivery pipes are each 6″ in diameter. The engines are furnished with counters.

Boilers.—These are of the multitubular improved locomotive type, manufactured by Messrs. Marshall & Co. The boilers capable of being worked to 90 lbs. steam pressure are in duplicate, each being 18 n.h.p.

Town Pumping Station.

Pumping Engines.—There are two horizontal Worthington's Compound Non-condensing Pumping Engines, capable of pumping 220 gallons per minute to a vertical height of 75 feet, with a steam pressure of from 60 to 80 lbs. per square inch on boilers.

The leading dimensions of each engine and pump are as under :—

High pressure cylinder	6″ diameter.
Low ,, ,, ...	9″ ,,
Water plungers	7″ ,,
Stroke	10″ ,,

Each pump works independently.

The suction and delivery pipes are each 6″ in diameter. The engines are furnished with counters.

Boilers.—These are of the multitubular improved locomotive type, manufactured by Messrs. Marshall & Co., capable of being worked to 90 lbs. steam pressure. They are in duplicate, each being 18 n.h.p.

The cost of the two sets of engine and boilers, including the cost of counters, was Rs. 39,436.

BHANDARA WATER-WORKS.

Specification of Pumping Machinery.

Pumping Engines.—Worthington Vertical Compound Non-condensing Pumping Engines, in duplicate, each of 18 h.p. and capable of discharging 300 gallons per minute, against a head of 200 feet. The leading dimensions of each engine and pump are as under :—

High pressure cylinder	9″ diameter.	
Low ,, ,,	14″ ,,	
Water plunger	8″ ,,	(double action).
Pump rod	2″ ,,	
Stroke	10″ ,,	
Normal speed	80″ feet per minute.	

Boilers.—These are of the multitubular semi-portable locomotive type, in duplicate, each being 15 n.h.p., capable of being worked to 90 lbs. steam pressure.

The boiler feed is by two donkey pumps, size 3″ × 2″ × 3″, supplying through a feed water heater.

The suction pipe is 8″ in diameter and the delivery 7″ fitted into an 8″ rising main.

The plant was manufactured by Messrs. James Simpson & Co. The cost of the engine and boiler was Rs. 37,836.

HINGANGHAT WATER-WORKS.

Specification of Pumping Machinery.

Pumping Engine.—The engine consists of a duplicate set of 14 h.p. Robey's Patent Horizontal Fixed Engines, each capable of discharging 225 gallons per minute, against a total head of 118 feet. The steam cylinders are $8\frac{7}{8}$″ diameter and the stroke is 14″. The engine crank shaft drives a pinion wheel geared into a spur wheel fixed on the shaft of the fly-wheel, and to the crank pin of the spur is fixed the pump rod.

The pumps are double acting bucket and plunger type, fitted with Harvey & Weston's double beat valves. The diameter of the pump barrel is 1 foot, the plunger $9\frac{1}{4}$ inches and stroke $2\frac{1}{2}$ feet.

Boiler.—These are in duplicate and of locomotive type. The pressure at which the boilers are ordinarily worked is 50 lbs.

The total cost of the engine and pump amounted to Rs. 28,077.

BULDANA WATER-WORKS.

THE PUMPING STATION IS 30 MILES FROM THE RAILWAY AND AN OIL ENGINE IS USED OWING TO THE HIGH PRICE OF COAL.

Specification of Pumping Machinery.

Hornsby Oil Engine.—The plant consists of a 9 h.p. Hornsby Oil Engine and a three-throw Plunger Pump. The oil engine was purchased for Rs. 2,160, and the pump for Rs. 975 from Messrs. Richardson Cruddas & Co., Bombay, and began to work on the 19th August, 1911.

The following are the leading dimensions of the oil engine :—

	Hornsby.
Working brake horse power	9
Fly-wheel, diameter in inches	51
,, width	6
Standard pulley, diameter in inches	20
,, ,, width in inches	9

The following are the leading dimensions of the three-throw plunger pump :—

	Hornsby.
Diameter of plunger in inches	6
Length of stroke ,,	8
Suction inlet diameter in inches	3
Delivery outlet diameter in inches	3
Pulley diameter in inches	24
,, width ,,	$6\frac{1}{2}$

HARDA WATER-WORKS.

Specification of Pumping Machinery.

Engines.—The engines, which are in duplicate, consist of Worthington's Vertical Triple Expansion, Surface Condensing Engines, with jacketed steam cylinders lagged with planished sheets in duplicate.

The pumps are of the Worthington's internal plunger pattern, double acting on both suction and delivery, with multiple india-rubber spring closed valves. The

plungers are $7\frac{1}{2}$" diameter. Each engine is capable of discharging 333 gallons per minute, against a head of 155 feet including friction.

Boilers.—The boilers are of the locomotive multitubular type.

The cost of the engines and boilers was Rs. 54,172.

RAIPUR WATER-WORKS.

Specification of Pumping Machinery.

Pumping Engines.—High pressure, triple expansion, direct acting horizontal Worthington's Surface Condensing Engines, in duplicate, each of 62 p.h.p., capable of discharging 556 gallons per minute, against a head of 184 feet including friction. The leading dimensions of each engine and pump are as under :—

High pressure cylinder	...	...	$6\frac{1}{8}$"
Intermediate ,,	...	...	$9\frac{1}{8}$"
Low pressure ,,	...	...	$14\frac{5}{8}$"
Main pump plunger	...	...	$8\frac{3}{8}$"
Normal speed	...	...	127 feet per minute.
Steam cylinders	...	...	Steam jacketed.
Working pressure	...	...	90 lbs.

All 15" stroke.

Boilers.—Boilers are of the Babcock and Wilcox's type in duplicate.

These were manufactured and supplied by Messrs. James Simpson & Co.

The cost of the engine and boilers was Rs. 36,633.

RAJNANDGAON WATER-WORKS.

Specification of Pumping Machinery.

Pumping Engine.—The pumping engines are triple expansion, horizontal Worthington's Surface Condensing Engines, in duplicate, each capable of discharging 200 gallons per minute, against a total head of 131 feet including friction. The leading dimensions of engine and pump are as under :—

High pressure cylinder	...	...	$4\frac{1}{2}$"
Intermediate ,,	...	...	7"
Low pressure ,,	...	...	11"
Main pump plunger	...	...	6"

All 10" stroke.

The steam cylinders are not jacketed, but covered with non-condensing composition and lagged.

Boilers.—The boilers are of the Babcock and Wilcox's type and are also in duplicate.

The cost of engine and boilers was Rs. 22,954.

Comparative Statement of Pumped Water Supplies in the Central Provinces for the year 1911-12.

Serial number.	Name of Water-Works.	Population supplied.	Average pump H. P. during year.	Cost of pumping per P. H. P. per hour.	Consumption of fuel per H. P. per hour.		Hours of pumping.		Cost of fuel per ton.	Duty per cwt. of coal in millions of foot-pounds.	Equivalent duty if best English coal had been used.	Capital cost of Plant.	Year of erection.	Remarks.
					Actual consumption with name of fuel.	Equivalent consumption of best English coal.	Average throughout year.	Maximum in one month.						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				Annas.	lbs.				Rs. A. P.			Rs.		
1	Nagpur High level	72,000	(*a*)37·53	(*a*)·95	(*a*)7·81 Jharia.	(*a*)6·24	(*a*)19·53	(*a*)22·33	11·65	(*a*)32·63	(*a*)40·79	43,886	1903	(*a*) Sitabuldi Engine.
			(*b*)72·93	(*b*)·83	(*b*)6·54 Jheria.	(*b*)5·23	(*b*)10·20	(*b*)11·53		(*b*)36·54	(*b*)45·68	1,23,400	1911	(*b*) Gorewara Engines.
	Wardha.													
2	River Station	12,540	9·02 (Bal.)	1·85	22·37 (Bal.)	10·02	14·24	18·83	9 1 0 (Bal.)	9·91 (Bal.)	22·30	..	..	
			10·11 (Jh.)		17·22 (Jh.)	13·77			11 5 8 (Jh.)	13·03 (Jh.)	16·29	39,436	1898	
	Town Station.		5·07 (Bal.)	2·63	28·80 (Bal.)	12·90	6·31	7·74	8 3 8 (Bal.)	7·71 (Bal.)	17·35			
			4·98 (Jh.)		24·81 (Jh.)	19·84			10 10 0 (Jh.)	10·74 (Jh.)	13·43			
3	Bhandara	14,000	13·47	1·46	30·29 F. W.	9·68	10·40	13	10 9 1 Jh. & Ch.	7·32 F. W.	20·58	37,836	1900	(*c*) Jheria and Chindwara coal has been used together and the equivalent of English coal is based on the average of Jheria and Chindwara coal.
					13·43 Jh. & Ch.	(*c*)9·67			4 12 6 F. W.	16·99 Jh. & Ch.	29·73			
4	Hinganghat	15,181	5·14	3·34	34·80 (Bal.)	15·59	17·52	18·87	8 8 8 (Bal.)	6·56 (Bal.)	14·76	28,077	1883	
					19·45 (Jh.)	15·56			14 12 8 (Jh.)	12·07 (Jh.)	15·09			
5	Buldana	3,820	2·74 Oil Engine.	5·91	1·80 Lbs. of Kerosine oil.		5·39 Oil Engine.	7·52	2 2 9 per tin.	(*d*)2·71		3,135	1911	(*d*) Per 4 gallon tin of oil.
6	Harda	16,300	11·0	2·06	19·78 Pench valley coal.	12·66	7·61	8·96	9 2 0	12·10	18·90	54,172	1910	
7	Raipur	35,335	29	1·05	8·03 Jh. & Rani-gunj coal.	6·42	12·71	17·38	9 15 7	28·10 Jh. & Rani-gunj.	35·13	36,633	1892	
8	Rajnandgaon	11,979	6·22	3·51	28·8 (Jh.)	23·04	7·90	11·6	8 1 5	8·02 (Jh.)	10·02	22,954	1893	

NOTE :—The cost of pumping includes fuel, small stores and establishment at pumping station. For equivalent consumption of best English coal the following values and co-efficients are taken, based on Government of India Circular No. XIV Railway, dated the 7th December 1904 :—

	Co-efficient.	Equivalent.
Taking the best English coal as	1·25	0·80
Ballarpur coal (Bal.)	·56	1·80
Umaria coal	0·80	1·25
Bengal (Jheria) best steam coal (Jh.)	1·00	1·00
Chindwara coal (Pench Valley) (Ch.)	0·80	1·25
Firewood F. W.	0·40	2·25

BENARES:

I.—DRAINAGE. II.—MINOR IMPROVEMENTS. III.—WATER-WORKS.

BY

MR. C. A. C. STREATFEILD, I.C.S.,

Chairman, Municipal Board, Benares.

I.—DRAINAGE.

1. The Drainage system of Benares city falls under three heads:—

(i) The old Nawabi drains.
(ii) The modern sewers.
(iii) The surface drains.

2. The Nawabi drains are old drains laid along under the lanes and streets, mostly with square inverts, and unscientifically laid. They take the contents of the house latrines, as well as all other dirty water from the houses, and are generally choked with filth, owing to their structural defects, and the absence of any proper flushing arrangements. There is not even a proper record of where these drains exist. They are at times cleared out at various points, when special complaints are made, but they are not cleared at all systematically.

Nawabi drains.

3. Steps are being taken to make more use of these drains. In the pacca mahals most of them have been taken in hand and improved. Their inverts have been cunetted and regraded, and automatic flushing tanks have been put in, so that they are nearly as efficient as modern sewers. Wherever possible they are connected with the modern sewers by a sufficiently large pipe to carry off all sullage and sewage, while they discharge their surplus storm-water down the old channel.

Improving the Nawabi drains.

4. Most of these old sewers lead into two old outfalls, the Trilochan sewers and the Dassasumedh sewer. Those leading direct to the river front have lately been connected up to the ghât intercepting sewer. (*See* para. 9).

The Trilochan sewer is a large sewer which was built in 1829 by Mr. Prinsep to drain the Maidagin Jheel, which used to exist where the Town Hall and Kotwali now stand. It received the outflow of many of the Nawabi drains of the pacca mahals. When the modern sewers were being made a considerable part of this drain was dismantled. The outfall of this sewer is at Trilochan Ghât, about ¾ mile above the Dufferin Bridge. The Dassasumedh Sewer has its outfall at the Dassasumedh Ghât about the middle of the city. This sewer was built about the time of the Mutiny, under the direction of Mr. Gibbins. It was laid along the bottom of an old nala, which nala was then filled in and made into a good broad road. As far as possible sewage and sullage are kept out of these sewers, but they both still bring some to the river front. As storm relief channels, however, they are both of great importance. They are now being repaired and improved.

Trilochan sewer.

Dassasumedh sewer.

5. The system of modern sewers is based on a scheme prepared by Mr. A. J. Hughes, Sanitary Engineer to Government in 1889. In the scheme as originally prepared there were two pumping stations on the main sewer but fortunately before the work was actually done, Benares was visited by Mr. Baldwin Latham, who examined the scheme, and without altering the general lines, so re-adjusted the levels that the whole main sewer discharged itself by gravitation.

Modern sewers.

6. This scheme forms the backbone of our drainage system. Its aims were definite, and it did not provide for everything. What it did provide for were:—

Limitations of Mr. Hughes's Scheme.

(*a*) A system of main drains, intercepting sewers, and laterals reaching most parts of the town.

(*b*) Latrines, pail depôts, and bathing platforms discharging into these drains.

What it did not provide for were:—

(i) Storm-water.
(ii) Reaching the houses.

7. Most of the drains and laterals have been put in, and more than half of the latrines proposed. A good many urinals have been put about the city, but only a few bathing platforms have been built, and those are not much used. Some pieces of work have been put in to give relief from storm-water, but no general storm-water survey or scheme has been prepared yet; for reaching the houses, a system of surface drains has been adopted.

8. This brings us to the surface drainage system. As the drainage scheme progressed it seems to have been felt that although the drains have a simple means for removing the sewage of the town, yet the ordinary householder got little benefit from it, and it was desirable to bring the drains to the houses. Hence a system of surface drains was introduced, which took the sullage from the houses, and in most cases led it to the sewer system. It is, I believe, Mr. Lane Brown that we have to thank for working out this system of removing the sullage nuisance. Various blocks of the town have been done in this way, but there is still a large part where the surface drains have not yet been put in, owing to lack of funds.

Surface drains.

9. Recently two modifications in the general drainage scheme have been introduced. One in a long branch sewer starting from near the Ishwari Hospital, and going past the kutcherries, thus bringing an outlying part of the municipality into the area commanded by the sewers. The other is a sewer along the ghât front between Dassasumedh and Trilochan, which has taken up all the small discharges which used to defile the ghâts all along. Now all these are collected into one sewer and discharged at one place. This is not an ideal way of dealing with the matter, but has effected a great improvement in the cleanliness of the ghâts.

Orderly Bazar branch sewer.

Ghât Intercepting sewer.

This was a particularly difficult piece of engineering, but has been done very successfully by Mr. Bailey, the Municipal Engineer.

Problems remaining.

10 There are some problems still to be worked out. I will mention some of them: —

(*a*) A general scheme for disposing of storm-water.
(*b*) The best use to make of the Nawabi sewers.
(*c*) How to get the public especially in the pacca mahals to connect their houses with the drains through proper disconnecting traps.
(*d*) How far the under-ground sewers should be extended to parts which now only have surface drains.
(*e*) Stone paving of all lanes.
(*f*) Completion of kerb and channel drains along the roads, and surface drains into the lanes.

11. The modern sewerage system of Benares may be said to consist at present of:—

1. 30 miles of brick and pipe sewer, ranging from 6 in. to 8 ft. in size.
2. 28 public latrines, on the water-carriage system, with 1,200 seats.
3. 26 Pail depôts.
4. 25 Public urinals.
5. 2,100 House connections, with disconnecting traps.
6. 70 miles of surface drains.
7. 5 miles of old Nawabi drains, which have been improved. The daily discharge at the outfall is 3,000,000 gallons.

12. I have to thank Mr. Bailey, the Municipal Engineer, Benares, for kindly looking over these notes and making valuable suggestions, and corrections.

A map of Benares city, with the modern sewers marked on it, is attached to this report.

II.—MINOR IMPROVEMENTS.

1. The municipality has erected a dhobi ghât near Reori talao. It was built on a plan suggested by a Sanitary Officer of experience and it has been adjusted more than once to try and meet the wishes of the local dhobis, but so far without success. For some reason the dhobis will not take to it.

2. The market at Bishesharganj has recently been built by the municipality. It has been built on what are hoped to be sanitary principles, but the attempt to make it rat-proof by making the stone floor project was not found a success as the projecting part was so liable to get broken.

3. Two town improvement schemes have been carried out in recent years. One is the new road from the Alaipura Railway Station to Bishesharganj, which is now completed. The other is the Raja Harischandra Road, which has been made over what was a nala, and gives a good broad road leading from the Assi

Road to the river front. This work although nearly completed, still has some work to be done on it.

4. There are three or four other schemes for town improvement, or town extension, but they are still in the initial stages. The two that are most advanced are: (1) a cross road near the Madanpura Latrine; and (2) a large town extension scheme towards Merwadih. If the Conference is interested and has time, I can explain these on the spot.

III.—WATER-WORKS.

Source of supply.

1. The water is taken from the Ganges at Bhadaini, from there it is pumped up to Bhelupur, where it is filtered and pumped into the city.

Gravitation pipes from the river.

2. At Bhadaini the water comes from the river into the suction well by gravitation. There are three gravitation pipes, the high, the middle, and the low gravitation pipes. The top of the low gravitation pipe is at level 187·33, whereas the lowest recorded level for the Ganges is about 189. Thus the margin between the lowest level, and the level of the pipe is not great, and the flow into the suction well at the time the river is lowest, is only just sufficient to keep the pump supplied. One question which we have to consider and settle is whether some steps, and if so, what, should be taken to provide for a greater margin of safety when the river is low.

Pumps at Bhadaini.

3. There are two sets of pumps at Bhadaini. The old set of beam engine pumps are now used as a stand by, to be employed whenever the new Worthington pump is being repaired or overhauled. The new pump was only finished in 1910. This pump is capable of pumping half a million gallons per hour, and as the present consumption of water in the city is now only about 4,000,000 per diem, there is an ample margin of power.

Boilers and Mechanical Stokers.

4. When the new pump was being put in, a new pair of boilers, Babcock & Wilcox boilers, with chain grate mechanical stokers, were put in.

Rising mains.

5. With the old pumps there was only a single rising main. It was a cast-iron 24-inch pipe. The old pumps were only supposed to send up $\frac{1}{4}$ of a million per hour. When the new pump capable of throwing up half a million was to be erected, a second rising main was laid, a steel lock bar pipe. This lock bar pipe has given a lot of trouble. There have been frequent leaks, not only at the joints, but also along the lock bars. In any case the steel appears to be too thin, being only 3-16 inch thick. Also there is a considerable contraction and expansion when the strokes of the pump cause variations in pressure. The question as to how best to remedy the defects in the steel rising main is one that has been exercising the municipality for some time.

Leaks on the Lock Bar Rising main.

Settling Tanks.

6. These rising mains lead into the settling tanks, for the sake of economy they both lead into a single pipe before they reach the settling tanks. This however appears to increase the pressure, and the hammering in the pipes, so a second connection to the first settling tank is to be made soon.

Continuous flow in the settling tanks.

7. There are three settling tanks. Originally the plan was to pump into one, while a second was settling and water was being drawn off from the third. Now, however, they are arranged so that the water can all be pumped into No. 1 and after flowing through No. 2 is drawn off from No. 3. This system was evolved here at Benares, by the local officers, and is, I hear, being followed elsewhere. Another contrivance for improving the settling tanks that has been adopted here is to use the silt from the tanks to strengthen and raise the banks.

Prefiltering scheme.

8. At this point it may be well to mention the prefilters. Under the present system, it is found that when the river is turbid, enough of the mud cannot be removed by mere sedimentation. In order to get over this difficulty, the municipality wishes to have a set of prefilters. It has not yet been decided which system of prefiltration will be adopted, but Government is using these water-works as an experiment to try the various systems. Whatever system is adopted, there is one question which should be thrashed out. It is whether the prefilters should be put in before the settling tanks or between them and the slow filters. The advantages of putting the prefilters before the settling tanks are:—

Prefilters before or after the settling tanks.

1. It will never be necessary to empty the settling tanks for cleaning. This will save between Rs. 1,000 and Rs. 2,000 per annum.

2. The whole of the settling tanks can be used as a reserve, in case of any breakdown at Bhadaini, or in the rising mains. This will also allow

the engines at Bhadaini to take a whole day or two off at regular intervals to allow for a thorough overhauling.

3. It will allow the pumps at Bhadaini to work steadily at their most economical speed, instead of having to adjust their speed to the filters.
4. It must be more economical in coal to run continuously for several days and then to shut down for a day or two than to work for a certain number of hours each day and bank the fires for the rest of the day.

The disadvantages are :—

1. It will be necessary to put in larger prefilters to deal with the full volume sent up by the Bhadaini pumps.
2. It is probable that water already filtered deteriorates bacteriologically, if kept standing.
3. It will be more costly to put the prefilters at a level that will allow them to discharge into the settling tanks.

Slow sand filters.

9. From the settling tanks the water goes to the slow sand filters. There are 8 of these, each 200 feet by 100 feet. They are not all identical. The latest lets its water in at one end, whereas the original ones let in their water through a pipe leading to the middle. Perhaps if they had been made later still, the water would have been let in over a well all along one side. It is worth noting that there are no regulators, or meters on the filters, so the rate of filtration is a very uncertain quantity. The difference of head between the filter and the discharge can be examined, and the extent to which the inlet valve can be regulated.

10. From the filters the water goes to the clear water reservoirs. I do not know that these call for any comment.

Pumps at Bhelupur.

11. The pumps at Bhelupur are the same as put in when the water-works were built 20 years ago. There are 4 pumps and engines, coupled into two pairs. This arrangement makes it difficult to work three while the fourth is being overhauled or repaired. With one pair working it is not possible to maintain sufficient pressure as long as the daily supply is limited to 4 or 5 million gallons which is given in 7 or 8 hours. With all four pumps going it is possible to keep up the pressure by concentrating the supply into a shorter time. However, this involves a sudden drop whenever one pair has to be closed owing to repairs or overhauling. One plan proposed to is to erect a third pair of pumps, but the policy being followed at present, is to increase the supply of water, when it is hoped that the hours can be extended, possibly up to 24 hours, and in 24 hours one pair of pumps can send 10,000,000 gallons into the city which would be ample, so only some balancing tanks would be needed, for one set to give ample power, while the second set was used as a spare.

Boilers at Bhelupur.

12. The boilers at Bhelupur consist of 3 Cornish, and 2 Lancashire boilers. The engines are supposed to work to a pressure of 100 lbs., but unfortunately the Boiler Inspector only allows 75 lbs. pressure in the 3 Cornish boilers. This involves loss of power and waste of coal. The Municipality is about to put in a new pair of boilers, very similar to the new ones at Bhadaini.

Balancing Tank.

13. The balancing tank is used as a reserve in case of a fire breaking out when the pumps are not working. It is also used to assist the pumps when they cannot keep up the pressure. It is considered a very fine bit of brick-work. Mr. Wilson, who was the Municipal Engineer when the work was done, put in a lot of exceptionally good brick-work both in the water-works and in the main sewer.

Water-wastage.

14. Outside the compound our great problem is water-wastage. The present consumption is only about 20 gallons per head. This however does not mean that everyone gets their 20 gallons but that some get more while the higher parts of the city get very little or none at all. Experimentally, I have tried what the consumption is in 24 hours, and in the coldest weather the consumption went up at once to 40 gallons per head. There is nothing to show what it would come to in the hot weather. We are attempting to increase our available supply by prefilters, but as experience in other parts of the world has shown that unless wastage is checked it grows with the supply, it has been decided to adopt the Deaconian system of district metering, and the Palatine Company have undertaken to put in the necessary valves and meters, and to start the system.

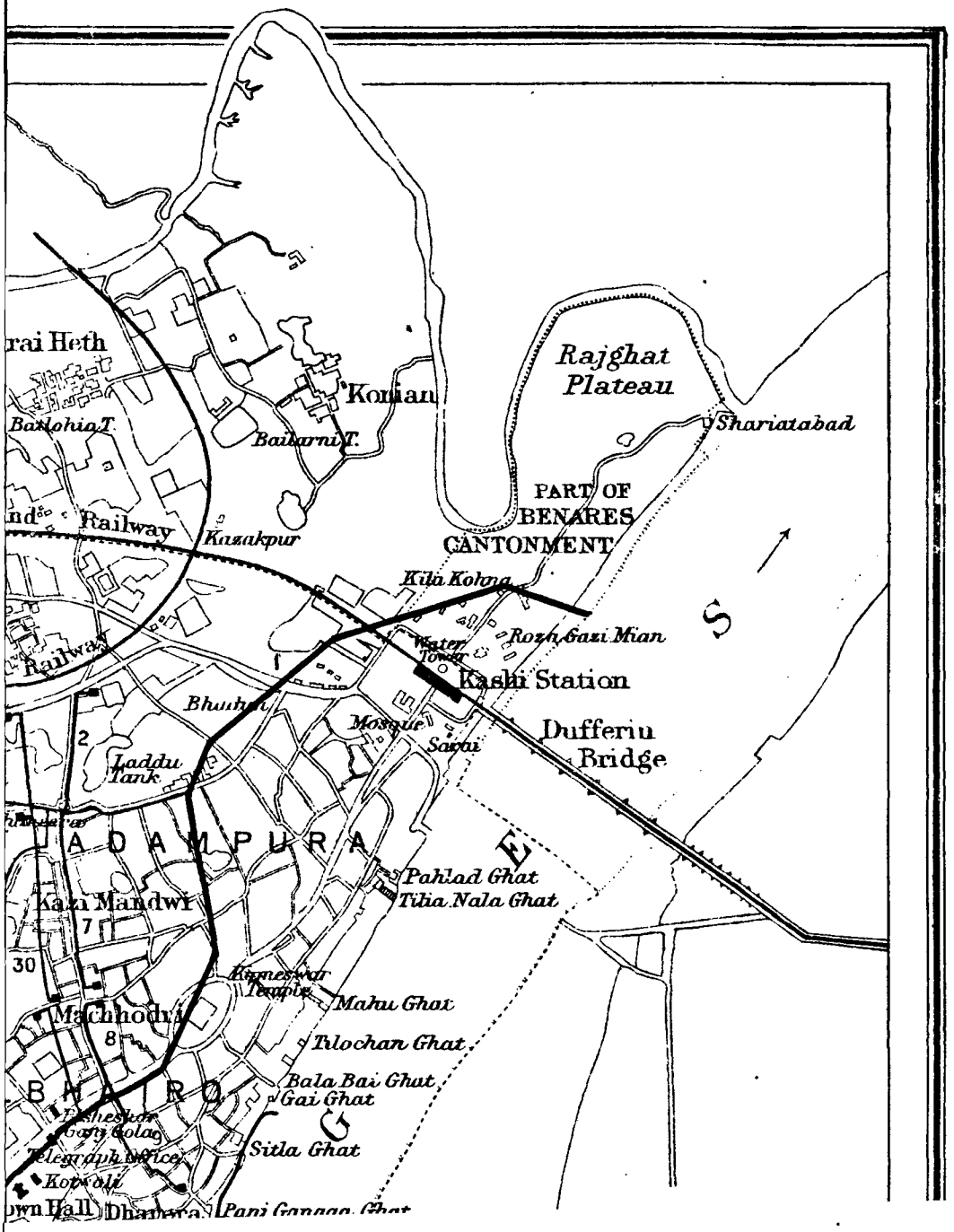
District metering.

Water consumption per head.

15. So far as I am aware, no one has settled what is the legitimate consumption in an Indian city. It would be extremely interesting to hear the experience of any town in India, if there is one which gives a continuous supply with a reasonable pressure. I do not know if there is such a town. Certainly this question of water-wastage is one of the biggest that has to be grappled with now by Indian Water-Works.

Benares has two disadvantages in trying to limit wastage. It has an exceptionally large number of house connections, over which it is almost impossible at present to keep any watch. Secondly, it has a fairly complete system of drains, so people can waste water, and let it run down the sewers, without suffering from dampness.

16. The Sanitary Engineer is preparing an estimate for erecting a balancing Tank in the heart of the city. At the time this note is written I have not seen the plan or estimate, but they should be ready long before January, and may be of interest.


rai Heth
Rajghat Plateau
Korian
Shariatabad
Railway
Kuzakpur
PART OF BENARES CANTONMENT
Kila Kotwa
Rozh Gazi Mian
Kashi Station
Dufferin Bridge
Bhuthan
Laddu Tank
JADAMPURA
Pahlad Ghat
Tilia Nala Ghat
Kaza Mandwi
Mahu Ghat
Tilochan Ghat
Bala Bai Ghat
Gai Ghat
Sitla Ghat
Kotwali
Dhanwa
Pani Ganga Ghat
BARO
Telegraph Office
2
7
30
8

BENARES
AND ENVIRONS
One English Mile
Pandepur
Danlatpur
Lunatic Asylum
Barna River
Oudh and Rohilkhand Railway
Bengal and North Western Railway
Sarai Rath
Konan
Rajghat Plateau
Sharsatabad
PART OF BENARES CANTONMENT
Kashi Station
Dufferin Bridge
Hukulganj
Alwinpur Sta.
Kamangarha
Sadullapur
JAITPURA
ADAMPURA
Kazi Mandwi
Jaitpura
Lachhipur
Baragaon
Collector's Court
Civil Court
Central Jail
Bank of Bengal
Post Office
Hotels
Sadar Bazar
CANTONMENT
Artillery Lines
Cantonment Station
Native Infantry Lines
Maldia
Nariyanpur
KOTWALI
CHAITGANJ
Sarae Aurangabad
Ramnagar
DASSASUMEDH
BHELSPURA
Sigra Mission Estate
Water Works
Bhadaini
Dashaswamedh Ghat
Manmandal Ghat
Munshi Ghat
Panda Ghat
Chausatti Ghat
Ganga Mahal Ghat
Amrit Rao Ghat
Narda Ghat
Chauki Ghat
Kedarji Ghat
Lali Ghat
Shivala Ghat
Bachhraj Ghat
Rat Baliya Saha. Ghat
Tulsi Ghat
Asni Ghat
Asni Sangam S.
Rajghat Fort
Rajghat Bridge
Rajghat Station
Mansarowar Ghat
Tilka Nala Ghat
Mehu Ghat
Telochan Ghat
Bala Bai Ghat
Gai Ghat
Sitla Ghat
Panj Ganga Ghat
Dalpat Ghat
Mangla Gauri Ghat
Ram Ghat
Gangat Ghat
Sakta Ghat
Sankatha Ghat
Raj Rao Ghat
Mandakranka Ghat
Puri Jalsai Ghat
Umrao-gir Bandh Ghat
REFERENCES

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